TM-1405GE Series Gigabit Ethernet Cameras

Operation Manual

10167
Rev. C

iAi PULNiX®
Imaging Products

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Warranty

For information about the warranty, please contact your factory representative.

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CE Compliance

The TM-1405GE series of cameras have been certified to conform to the requirements of Council Directive 89/336/EC for electromagnetic compatibility and to comply with the following European Standards:

Emissions: EN 55022A: 1998 + A1: 2000 + A2: 2003
Immunity: EN55024: 1998 + A1: 2001 + A2: 2003

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WARNING

Changes or modifications to this unit not expressly approved by the party responsible for FCC compliance could void the user's authority to operate the equipment.

TM-1405GE Series Operation Manual
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Table of Contents

1 Software Introduction 1
1.1 Scope of the Document 1
1.2 Related Documents 1
1.3 Gigabit Ethernet Camera Interface 1
1.4 Software Installation 2
1.4.1 Before Installing the GigE Series Camera-Control Software 2
1.4.2 Installing the Software 2
1.4.3 Uninstalling the Software 3
1.4.4 Quick-Start 3
2 Connectors 5
2.1 Power and Signals Connector 5
2.2 Ethernet 6
3 Configuring the TM-1405GE Camera 7
3.1 Setup 7
3.2 Configuring the Imager 9
3.2.1 GUI Features 10
3.3 Configuring the Internal Frame Grabber 10
3.4 Modes 10
3.4.1 Check the Current Camera Setting 10
3.4.2 Exposure Control 11
3.4.3 Scan Mode 12
3.4.4 Gain Settings 13
3.4.5 Offset Level 13
3.4.6 Auto Black Level 13
3.4.7 Look-Up Table 14
3.4.8 Memory Pages 14
3.4.9 Free-Running Mode 15
3.4.10 Externally Triggered 15
3.4.11 Internally Triggered 15
3.4.12 Save/Restore Settings to Your Hard Disk 15
3.4.13 White Balance Control (Color Versions Only) 16
3.4.14 Main Menu: Option 16
3.4.15 Version 16
3.4.16 Exit 16
4 Signal Handling 17
4.1 Camera Inputs 17
4.2 GPIO Control Block 18
4.3 GPIO Label Tables 20
4.4 Pulse Generators 22
5 GigE Series Camera Serial Commands 23
6 Hardware Introduction 27

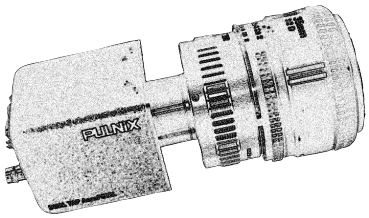
6.1 Product Description 27
6.2 Features 28
7 Installation 29
7.1 Getting Started 29
7.1.1 Unpacking Instructions 29
7.1.2 Components 29
7.1.3 Accessories and Options 29
7.2 Camera Setup 30
7.2.1 Heat Dissipation 30
7.2.2 Connector Pin Configurations 30
7.2.3 Power Supplies and Power Cable Setup 31
7.2.4 Attaching the Camera Lens 33
8 Operation 34
8.1 Progressive Scanning 34
8.2 Bayer Color Filter (Color Versions) 35
8.2.1 Color Filter Array 35
8.2.2 Bayer Color Filter Array (CFA) 35
8.2.3 Starting Pixel Configuration 36
8.2.4 Sync and Data 37
8.2.5 Camera Functions 37
8.2.6 Interpolation Software 38
8.2.7 Color Interpolation 38
8.3 Electronic Shutter 38
8.4 External Sync 39
8.5 Asynchronous Reset 39
8.5.1 Async No Shutter 39
8.5.2 Internal Direct Shutter Speed Control 40
8.5.3 External VINIT With Pulse Width (No-Delay Shutter) 40
8.5.4 Async Direct Shutter 42
8.6 Programmable Look-Up Table (LUT) and Knee Control 42
8.7 Camera Timing Charts 43
8.8 Video Output 45
8.9 External HD Locking and External VD Reset 46
8.10 Asynchronous Reset 46
9 Troubleshooting 48
9.1 Problems and Solutions 48
9.1.1 Symptom: No Video 48
9.1.2 Symptom: Dark Video 48
9.1.3 Symptom: Non-Synchronized Video 48
9.2 Information and Support Resources 49
10 Appendix 50
10.1 Specifications 50
10.1.1 TM-1405GE Physical Dimensions 51
10.1.2 Spectral Response 52

List of Figures

Figure 1. Scanning for Drivers 3
Figure 2. Intel Pro Install Choices 3
Figure 3. Change and Remove Buttons 3
Figure 4. Network Device Finder Window 3
Figure 3. Select Camera Window 4
Figure 4. TM-1405GE Back Panel Connectors 5
Figure 5. HR10A-10R-12P 6
Figure 6. Ethernet GigE Socket 6
Figure 7. Camera Interface Application Dialog Box 7
Figure 8. Advanced Configuration Window 8
Figure 9. Integrated GigE Camera Software 9
Figure 10. Advanced Configuration - Port Communication 11
Figure 11. Exposure Control 11
Figure 12. Mode Control Pull-down 12
Figure 13. Shutter Speed 12
Figure 14. Scan Mode 12
Figure 15. Gain Settings 13
Figure 16. Offset Level 13
Figure 17. Auto Black Level 13
Figure 18. Look-Up Table 14
Figure 19. Memory Pages 14
Figure 20. White Balance Control Settings 16
Figure 21. GE Camera GPIO Control Block 18
Figure 22. GPIO Look-Up Table 19
Figure 23. The GPIO Configuration 19
Figure 24. Pulse Generator Page 22
Figure 25. 12-Pin Connector Pinouts 30
Figure 26. GigE Ethernet Connector 31
Figure 27. 12P-02S Interface Cable (optional) 32
Figure 28. Example of Color CCD CFA Pattern 36
Figure 29. Example of TMC-4100GE (Same as TM-4100GE) 37
Figure 30. Async No Shutter 39
Figure 31. Internal Direct Shutter Speed Control 40
Figure 32. No-Delay Shutter 41
Figure 33. Asynch Direct Shutter 42
Figure 34. Physical Dimensions 51
Figure 35. Spectral Response 52

TM-1405GE Software

Operation Manual



1 Software Introduction

1.1 Scope of the Document

This manual describes how to access and use features specific to JAI PULNiX's Gigabit Ethernet camera, the TM-1405GE. The camera's different operation modes are described in the hardware section of this manual, which begins on page 27.

The TM-1405GE series consists of the TM-1405GE (monochrome) and the TMC-1405GE (color). Unless otherwise noted, all information contained in this manual is relevant to both models.

1.2 Related Documents

The appendix contains descriptions of the TM-1405GE camera's internal frame grabber and how to connect the camera. The appendix complements, and should be used in conjunction with the three following documents:

- *Cam2Net User's Manual*
- *Cam2Net IP Device Drivers*
- *Cam2Net C++ SDK Reference Manual*

These documents are part of the GigE software package and are added to your system when the software is installed.

1.3 Gigabit Ethernet Camera Interface

The GigE interface provides an easily connectable, high-bandwidth imaging solution, where video data is sent as IP packets over an industry-standard GigE network.

Point-to-point (unswitched) transmission is up to 100 meters. With Gigabit Ethernet switches, the transmission distance is virtually unlimited.

Note: Refer to the section on time-outs and packets in the *Cam2Net User's Manual* for more information on packet sizes for point-to-point and networked applications.

Communication with a GigE camera is completely user transparent, so if you usually work with Camera Link® or the JAI Cam2Net adapter, you will find it very easy to migrate.

The TM-1405GE camera has internal frame memory, which sends only the actual image data using the Gigabit Ethernet interface.

At the PC, the *Cam2Net Software Development Kit (SDK)* provides a communications interface that maps the RS-232 command channel through the IP link. All commands sent to and received from the camera are transparently routed to/from the host PC using the GigE link.

Refer to the *Cam2Net User's Manual* for details about network requirements, compatibility, and so on.

1.4 Software Installation

The following instructions explain how to install the JAI PULNiX GigE camera-control software on a PC.

1.4.1 Before Installing the GigE Series Camera-SDK Software

Before installing the JAI PULNiX GigE camera-SDK software, please note the following requirements.

- Your computer must have a Pentium processor running at least 1.4GHZ, and its operating system must be either Microsoft Windows XP Pro or Windows 2000.
- Installation of the software requires approximately 75 MB of free space in your PC hard disk.

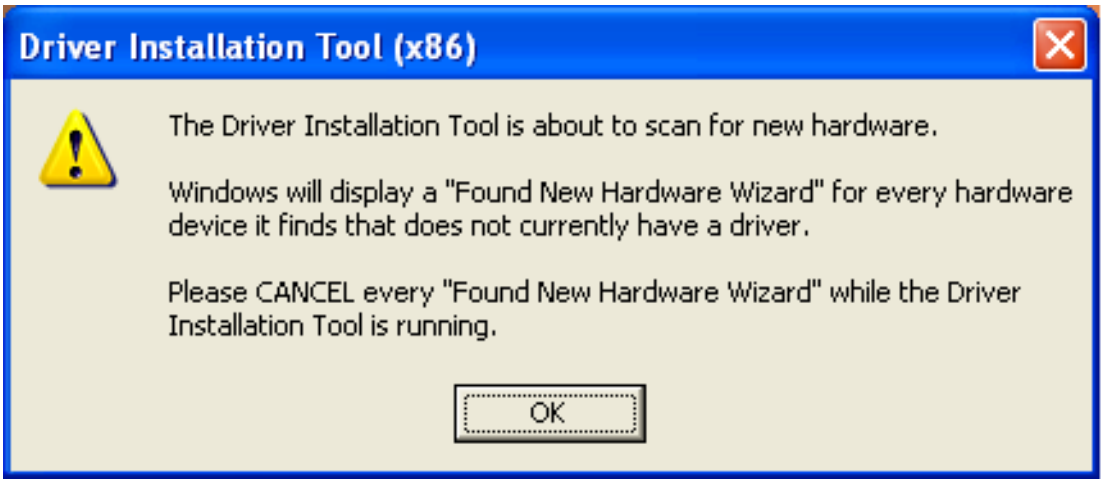
1.4.2 Installing the Software

To install the JAI PULNiX GigE camera-control software, read and follow the directions included in the document download card. If your computer does not have Internet access, call JAI PULNiX at 1 800 445 5444 to request that the software be sent to you on a CD-ROM.

Install the software using the following steps:

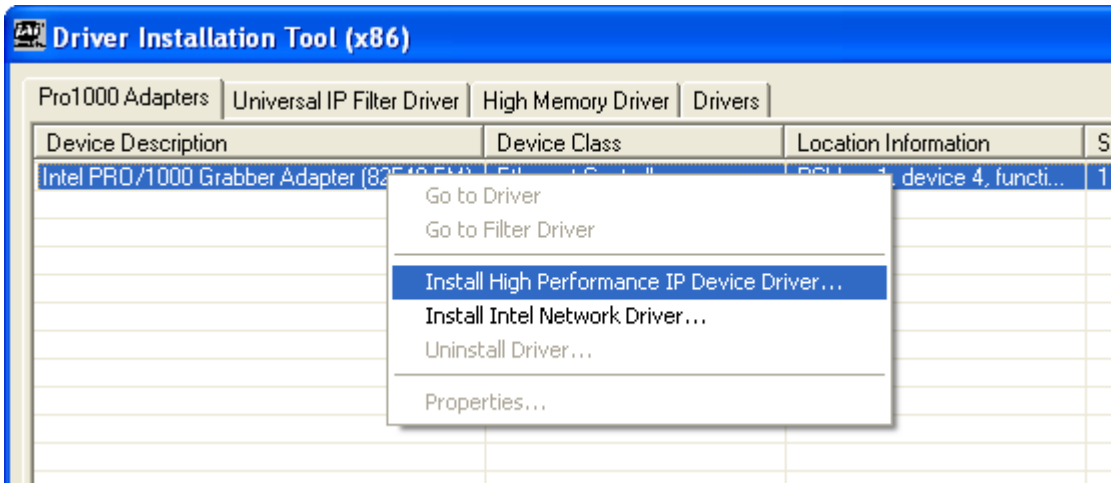
1. Open the folder "JAI" and run the IPEngineSDK.exe file to install the Camera Interface Application.
2. Open the folder "GigE_Software" and run the setup.bat file. This installs the GigE camera software as part of the Camera Interface Application. It copies the file cycampulnix.dll to the folder C:\Program Files\JAI\Cam2Net\Binaries.
3. The program initiates a driver scan. Allow the network card driver installation at this time. (If you cancel the installation for some reason this dialog box can be accessed at a later time; go to "**Start" --> "Programs" --> "JAI AS" --> "Launch Driver Installation Tool"** to launch the driver install).
4. A driver installation tool dialog box displays. Read the message about canceling *found new devices* and then click **"OK"**.

Figure 1. Scanning for Drivers


Driver Installation Tool (x86)
The Driver Installation Tool is about to scan for new hardware.
Windows will display a "Found New Hardware Wizard" for every hardware device it finds that does not currently have a driver.
Please CANCEL every "Found New Hardware Wizard" while the Driver Installation Tool is running.
OK

5. The Driver Installation Tool dialog box appears with a listing of all NIC cards on the system.
6. Right click on the net driver desired for the camera. If the driver is an Intel Pro a high performance option is available for install.

Figure 2. Intel Pro Install Choices



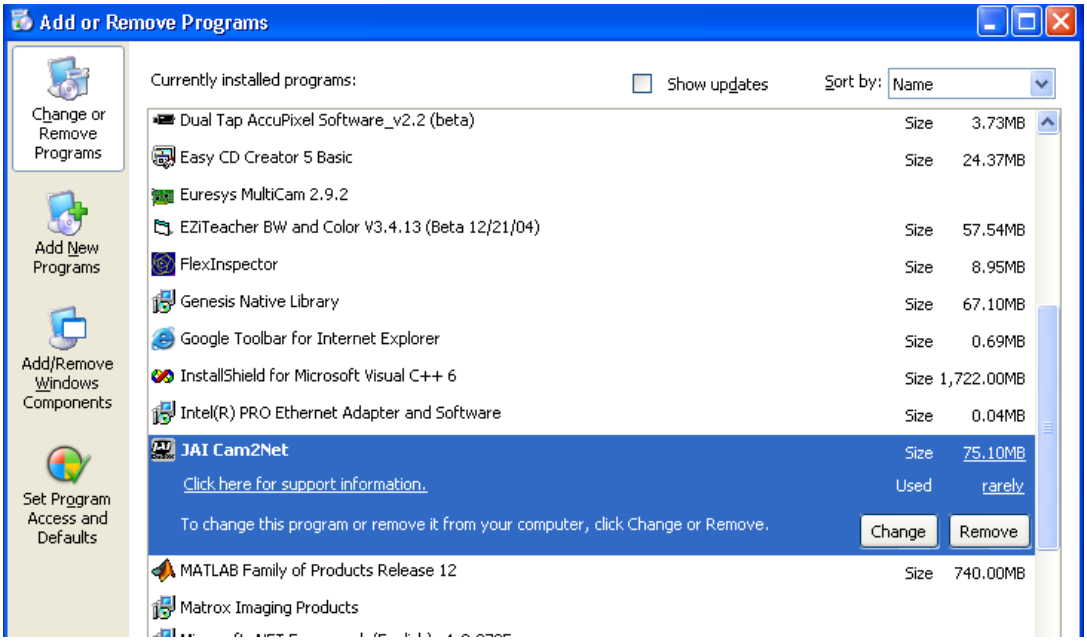
7. Right click on the net driver desired for the camera.
8. Select the desired driver install **"Install High Performance IP Device Driver"** or "**Install Intel Network Driver"**. The network installation options vary, based on the NIC card installed on the system. A dialog box asks for verification of the selected install. Click "Yes". Follow the instructions on any additional dialog boxes.
9. For information on other network card installs click "Start"-->"JAI A.S"-->"Cam2Net"-->"Documentation"-->"Cam2Net IP Device Drivers". An Acrobat file has instruction to help guide you through the proper install.
10. Go to "**Start" --> "Programs" --> "JAI AS" --> "Cam2Net**" --> **"Launch Coyote application"** to launch the camera control tool.

1.4.3 Uninstalling the Software

To uninstall the JAI PULNiX GigE camera-control software from the control panel, use the following steps:

1. Open “Add or Remove Programs” in the control panel.
2. Select “JAI Cam2Net” from the lists of the installed software.
3. Click the “Change or Remove” button as shown in Figure 3.

Figure 3. Change and Remove Buttons

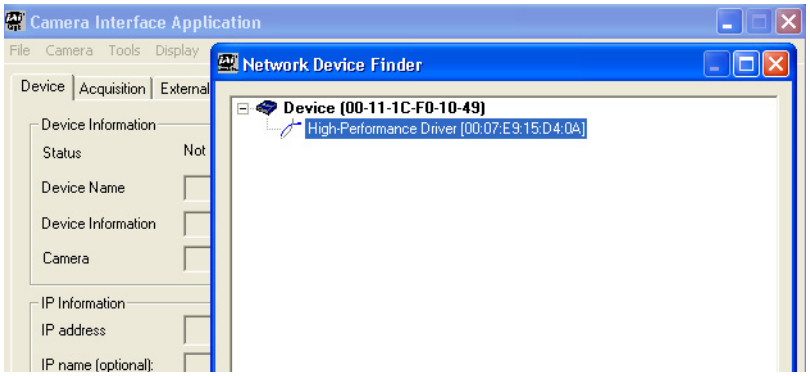

Add or Remove Programs
Change or Remove Programs
Add New Programs
Add/Remove Windows Components
Set Program Access and Defaults
Currently installed programs:
Show updates
Sort by: Name
Dual Tap AccuPixel Software_v2.2 (beta) Size 3.73MB
Easy CD Creator 5 Basic Size 24.37MB
Euresys MultiCam 2.9.2
EZiTeacher BW and Color V3.4.13 (Beta 12/21/04) Size 57.54MB
FlexInspector Size 8.95MB
Genesis Native Library Size 67.10MB
Google Toolbar for Internet Explorer Size 0.69MB
InstallShield for Microsoft Visual C++ 6 Size 1,722.00MB
Intel(R) PRO Ethernet Adapter and Software Size 0.04MB
JAI Cam2Net Size 75.10MB
Click here for support information. Used rarely
To change this program or remove it from your computer, click Change or Remove.
Change
Remove
MATLAB Family of Products Release 12 Size 740.00MB
Matrox Imaging Products

1.4.4 Quick-Start

Use the following quick-start process when the Camera Interface Application is installed on your PC.

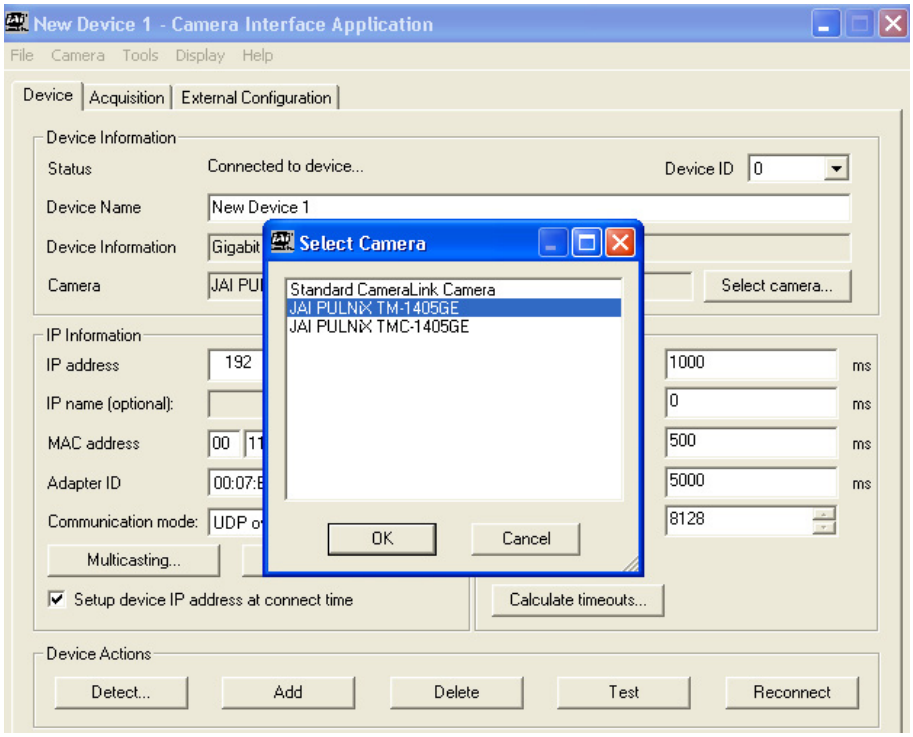
1. Connect the camera. The Hirose pin layout is shown in Table 1 on page 7. Both the Hirose and the network cable (RJ-45) are illustrated in Figure 6.
2. Run the Camera Interface Application.
3. Click “Detect.” Assign a suitable IP address to the camera. The window shown in Figure 4 appears.

Figure 4. Network Device Finder Window



4. Select the appropriate camera from the list, similar to the window shown in Figure 5 and click **OK**.

Figure 5. Select Camera Window



5. Go to the "Acquisition" tab and click **Start**. An image stream should appear.
6. Click **Configure** and open the "GigE Camera Software" dialog box. This is your integrated control software.

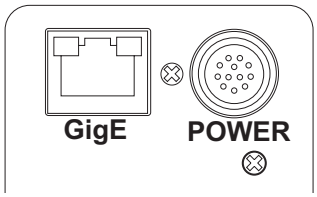
Note: the color version (TMC-1405GE) requires color interpolation to be performed in the frame grabber or by using the host computer's CPU. In default mode, the camera supports 2 x 2 color interpolation. For better color performance, the user can select 3 x 3 interpolation in the Camera Interface Application. Go to the "Acquisition" tab and click **Configure**. In the Advanced Configuration Window, select the "Pixel Type" tab. Make sure the camera is set to the proper color space and pixel depth, then click the check-box labeled "Use 3 x 3 Bayer Interpolation" in the "Conversion Options" panel. More information on color interpolation and the color filter array (CFA) can be found in Section 8.2 beginning on page 38 of this manual.

2 Connectors

The camera has two sockets, as shown in Figure 6 below:

- 12-pin Hirose for power, trigger, RS-232 communication and TTL I/O.
- RJ-45 for Gigabit Ethernet.

Figure 6. TM-1405GE Back Panel Connectors



These connectors are described in Section 2.1 and Section 2.2 below.

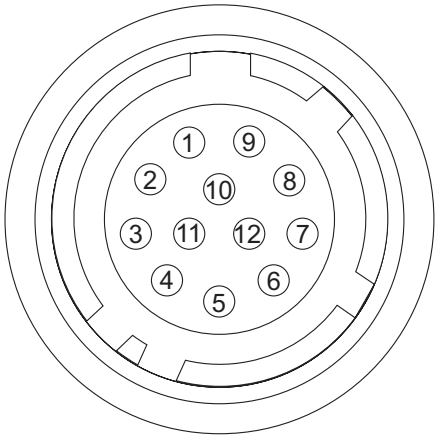
2.1 Power and Signals Connector

The GE camera receives power and signal through a 12-pin Hirose connector. Table 1 below lists the pin layout and describes the function of each pin. The table lists the GPIO assignments for the relevant pins. A magnified illustration of each pin's assignment follows in Figure 7 on page 8.

Table 1. Hirose Connector, Pin Assignment

Pin #	Definition	Description	GPIO Assignment
1	GND	Power ground	
2	+12V	Power supply in	
3	AGND	Analog ground (video)	
4	VIDEO	Video out	
5	GND	Ground (TTL) - Digital	
6	TTL IN (EXT_TRIG)	VINIT in (CC1 equivalent)	I0
7	TTL IN (EXT_VD)	VD in (CC4 equivalent)	I1 (can bypass GPIO LUT)
8	TTL OUT (STROBE)	Strobe output	Q0
9	TTL IN (EXT_HD)	HD in (CC3 equivalent)	I2 (can bypass GPIO LUT)
10	RESV	Reserved	
11	RESV	Reserved	I3
12	RESV	Reserved	

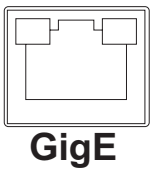
Figure 7. HR10A-10R-12P



2.2 Ethernet

The GigE socket, marked on the camera's back panel as "GigE," is a standard RJ-45 Ethernet socket. Use at least cat5e UTP cables (Cat6 cables are preferred). If you wish to connect the camera directly to a PC, you must use a cross-over cable. Refer to the *Cam2Net User's Manual* for details.[1]

Figure 8. Ethernet GigE Socket



1. JAI PULNiX recommends the use of shielded cables to reduce emissions and for CE/FCC compliance. Double-shielded cables will further reduce emissions.

3 Configuring the TM-1405GE Camera

The configuration of your GigE camera consists of two parts:

- The imager configuration (CCD and control circuits)
- The internal frame grabber configuration

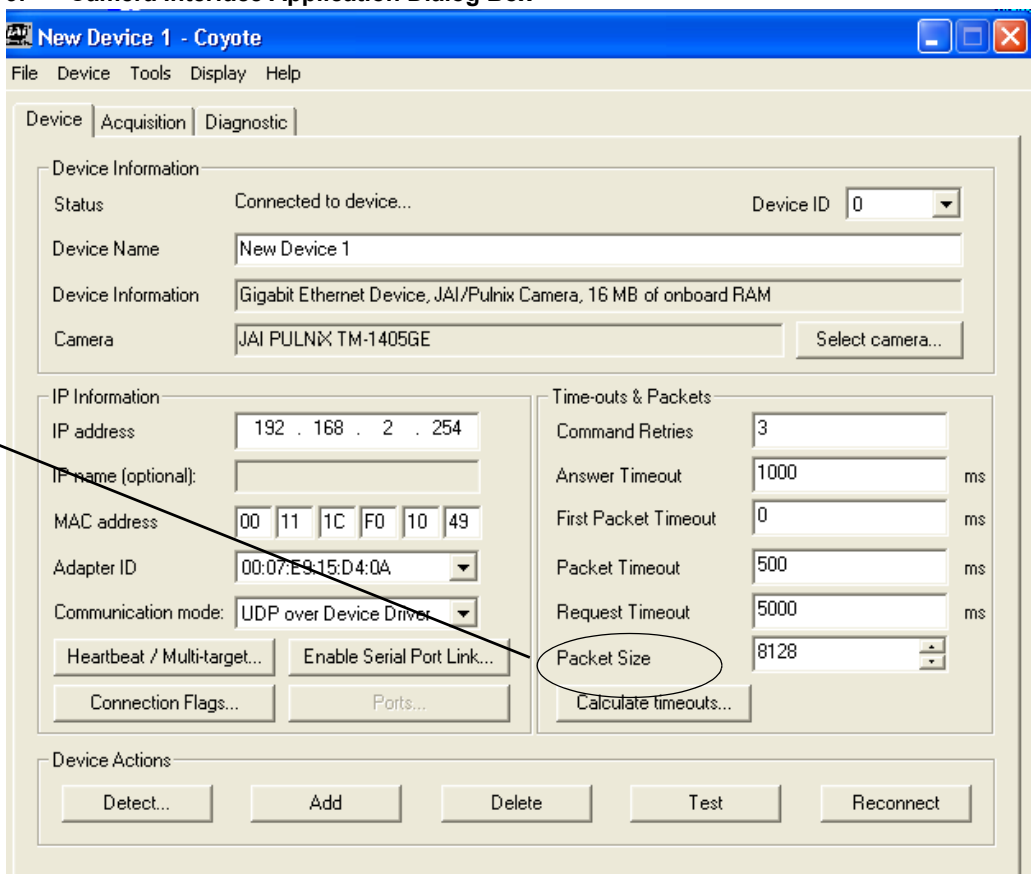
The imager can be configured for partial scan, just like a Camera Link camera. The internal frame grabber is automatically configured for the pixel type, windowing, image size and I/O and so on, by the GigE camera software.

3.1 Setup

If you have a peer-to-peer connection between the TM-1405GE camera and your PC without network switches, your packet size can be the default value (8128 bytes) as shown in Figure 9. However, if you are connecting the TM-1405GE to your PC through a network switch, then you need to know maximum packet size that your network switch supports. Typically, if your switch supports jumbo packets, then you should keep the packet size to 8128 bytes. If your switch does not support jumbo packets, then you may need to change the packet size to 1440 bytes.

Figure 9. Camera Interface Application Dialog Box

Note: If you connect the camera through a network switch, you may need to modify the packet size.

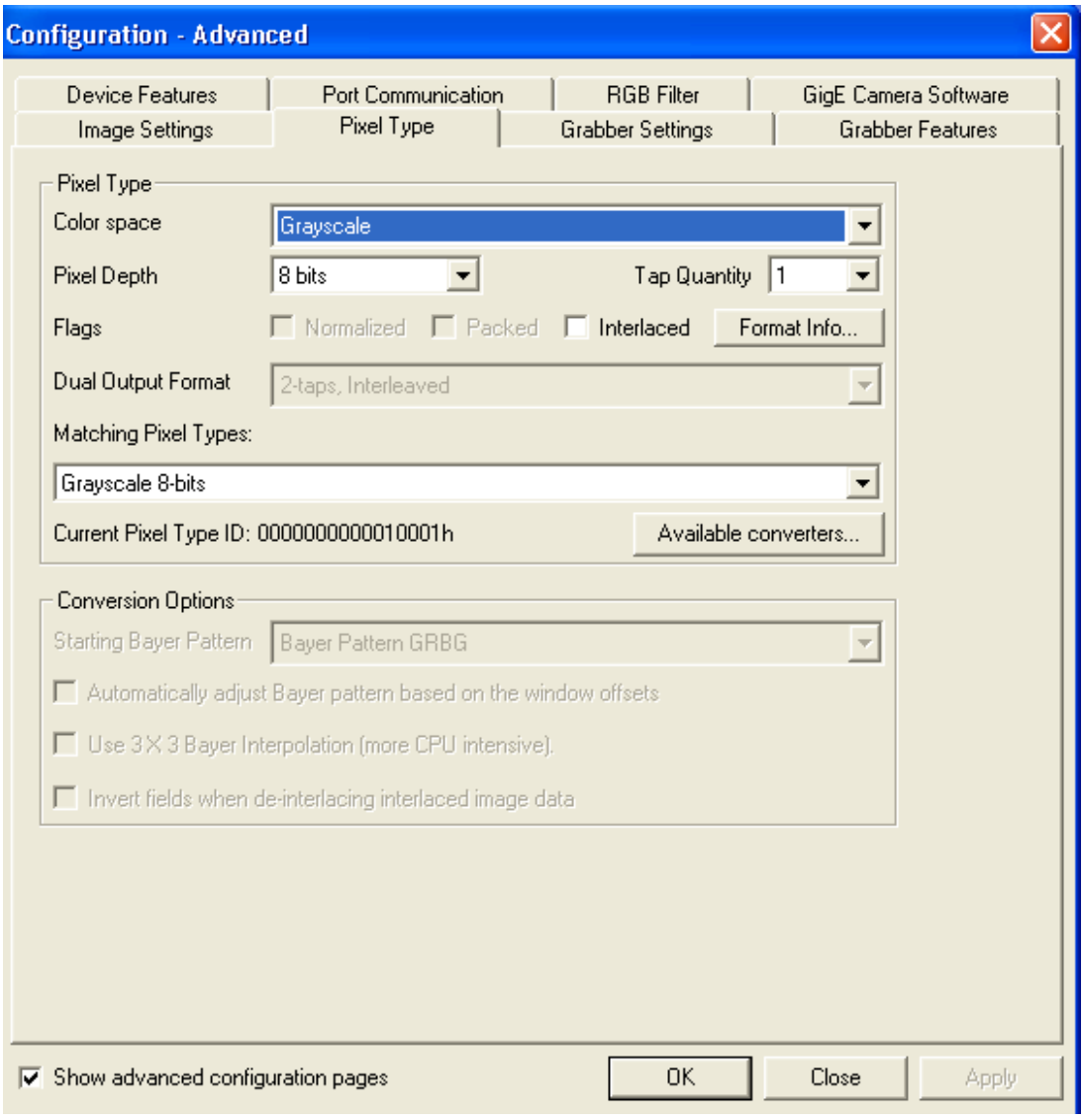


To use the integrated GigE camera software, use the following steps:

1. Start the Camera Interface Application. The dialog box shown in Figure 9 appears.
2. Click the **Detect** to detect the device and driver in the "Device Actions" panel.
3. Click **Select Camera** and select TM-1405GE or TMC-1405GE (color) from the camera list.
4. Select the "Acquisition" tab and click **Configure**. The camera configuration dialog box appears.
5. Select the "GigE Camera Software" tab. This is the Integrated GigE Camera Software shown in Figure 11 on next page.

The TM-1405GE camera can operate in either 8-bit or 10-bit digital output mode. The 8-bit/10-bit selection is possible through the GigE integrated software. To select the mode, open the Configure page and select the Pixel Type tab as shown in Figure 10. Under the Pixel Type, select either Grayscale 8, or Grayscale 10. Note that when Grayscale 10, 2 taps is selected, the LUT (Look-Up Table) is not available in this mode.

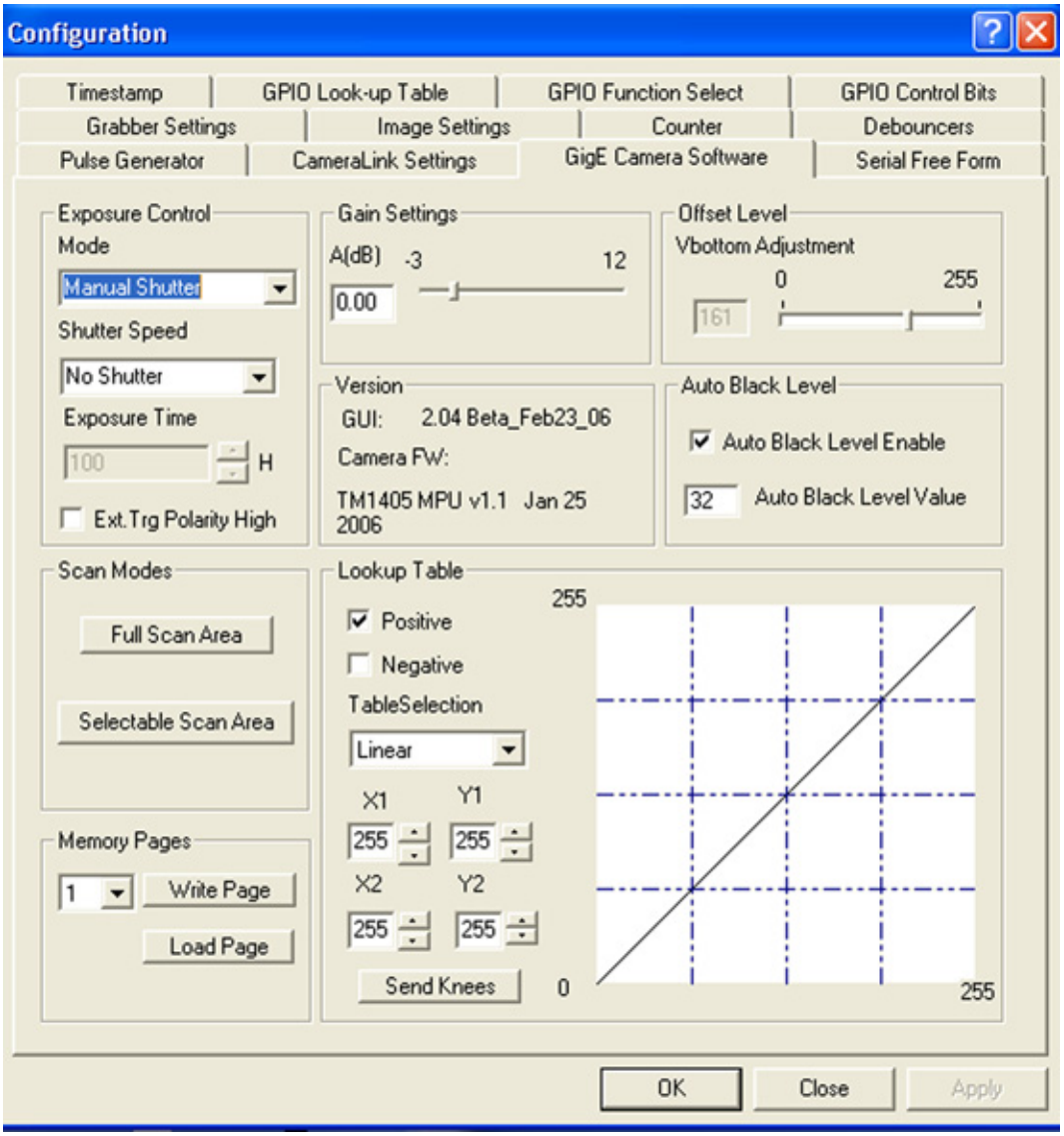
Figure 10. Advanced Configuration Window



3.2 Configuring the Camera

To configure the TM-1405GE's camera, use the integrated GigE camera software that is part of the Cam2Net camera interface application. You can also use the AccuPiXEL GigE control tool, but that will not update any internal grabber settings. "Hardware Introduction" on page 27 of this manual contains a description of the different image settings of the camera.

Figure 11. Integrated GigE Camera Software



3.2.1 GUI Features

You can control the following camera functions using the integrated camera software:

- Shutter Speed and Mode
- Scan Mode
- Gain Control
- Offset Level
- Memory Pages
- LUT (Look-Up Table) Control

3.3 Configuring the Internal Frame Grabber

The integrated camera software updates the internal frame grabber settings automatically. In addition, because the internal frame grabber configuration is independent of the imager configuration, you can set up (that is, "window") the internal frame grabber separately, for example, the Image Settings tab in the integrated camera software. This has the added benefit of reducing unnecessary traffic on the GigE network, therefore freeing bandwidth for other cameras.

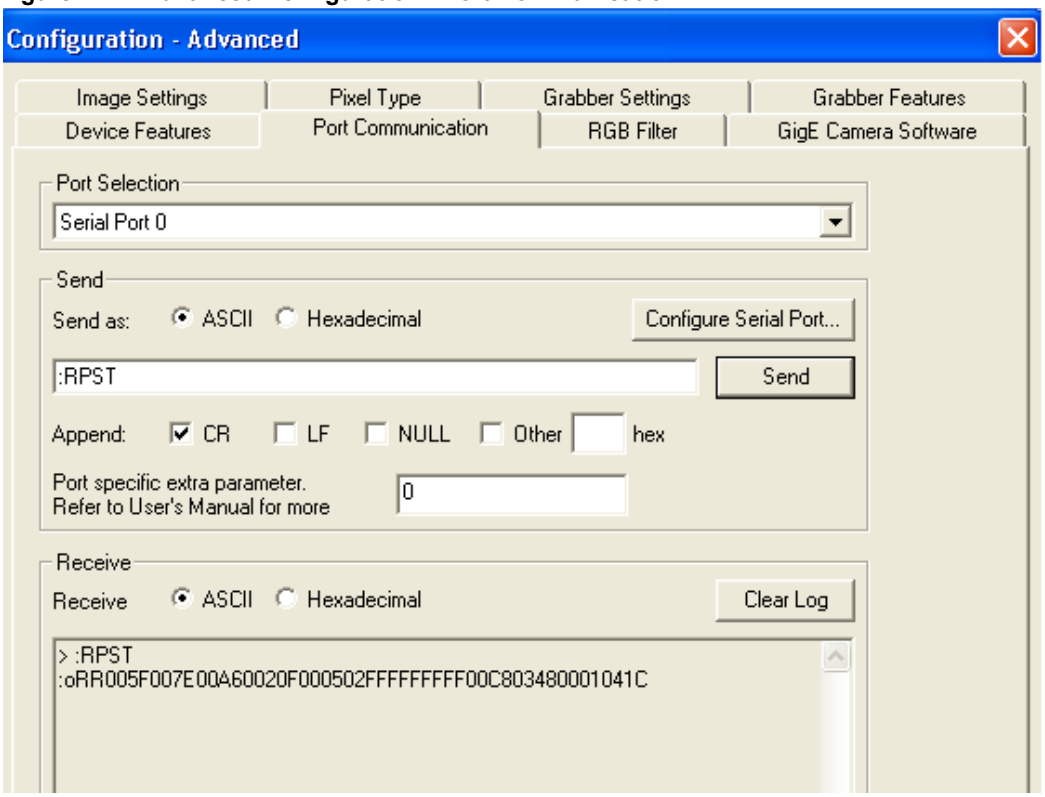
3.4 Modes

This section includes several examples of setup actions available through the camera configuration dialog box. Note that items 3.4.2 through 3.4.8 are all found under the GigE Camera Software tab of the configuration dialog, as previously shown in Figure 11.

3.4.1 Check the Current Camera Setting

You can manually send camera commands from the "Port Communication" tabbed dialog shown in Figure 12. Use the serial port and click the "CR" check box. Enter :RPST and click **Send** to get the current camera setting. For detailed information about the current camera setting, refer to Table 4 on page 25.

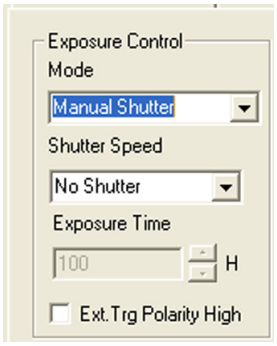
Figure 12. Advanced Configuration - Port Communication



3.4.2 Exposure Control

In Exposure Control, under the GigE Camera software tab, shown in Figure 13, you can specify the shutter mode and set the shutter speed and direct shutter values.

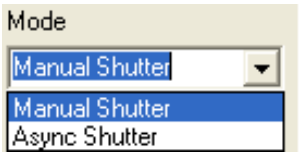
Figure 13. Exposure Control



Mode

Use the pull-down menu shown in Figure 14. to select from Manual or Async mode.

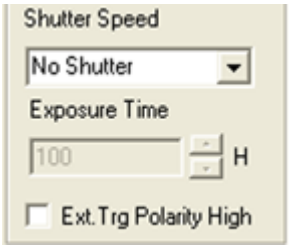
Figure 14. Mode Control Pull-down



Shutter Speed

The shutter speed setting, shown in Figure 15, allows you to select the specific shutter speed for Manual shutter and Async shutter. Manual shutter speed 0 is No Shutter mode; Async shutter speed 0 is Async - No Shutter mode; Async shutter speed 9 is Async - No Delay shutter mode (pulse width control). Direct Shutter allows you to select shutter speed for direct shutter count by the video line. External trigger polarity is set to active low in the Async mode.

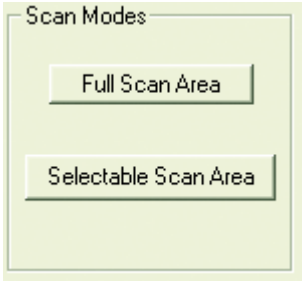
Figure 15. Shutter Speed



3.4.3 Scan Mode

The TM-1405GE camera has full and partial scan modes as shown in Figure 16. The partial scan area allows you to select the different scan lines. When the scan area starts from an odd line, for a color camera, an offset of 1 is added in the vertical direction.

Figure 16. Scan Mode



3.4.4 Gain Settings

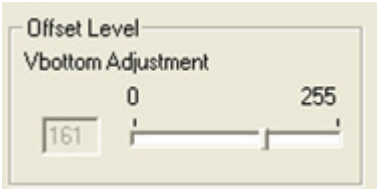
The Gain Settings control box, shown in Figure 17, allows you to change the Gain value from -3dB to 12dB. To change the value, move the slider or enter the value directly into the text box.

Figure 17. Gain Settings

3.4.5 Offset Level

The offset level box, shown in Figure 18, allows you to change offset voltage. To change the value, move the slider or enter the value directly into the box.

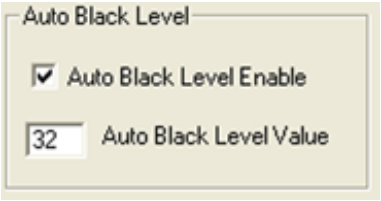
Figure 18. Offset Level



3.4.6 Auto Black Level

The Auto Black Level check box. shown in Figure 19, enables/disables the auto black level feature in the camera. A 10-bit value (in decimal form) is used for the auto black level. Vbottom adjustment is disabled if the auto black level is enabled. This feature is disabled by default.

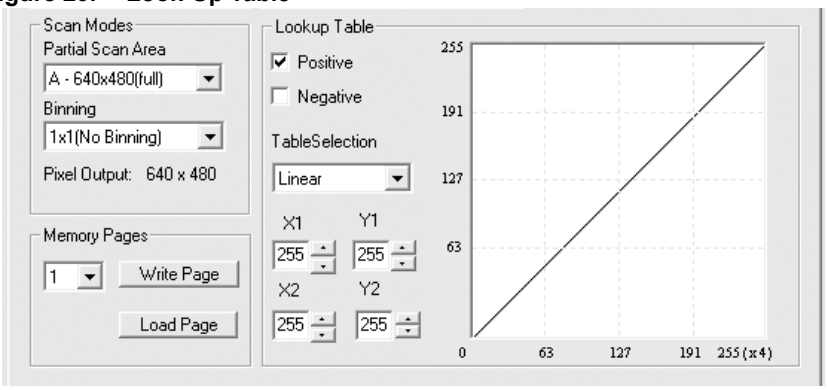
Figure 19. Auto Black Level



3.4.7 Look-Up Table

The look-up table (LUT) control, shown in Section 20 on page 16, allows you to change two knee point values.

Figure 20. Look-Up Table



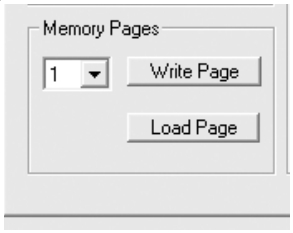
Enter X_1, Y_1, X_2, Y_2 values directly to adjust the knee curve. In the integrated camera software, the look-up table cannot be controlled interactively. The Table Selection pull-down menu allows you to select the Linear or Gamma 45 option. This control also allows you to check the positive or negative image option.

3.4.8 Memory Pages

All the camera parameters such as shutter mode, shutter speed, gain, offset level, scan mode, and LUT can be saved into seven (7) available memory pages on the EEPROM in the camera. The pages are numbered 0-6. The Load Page button loads the corresponding camera settings from the EEPROM while the write page button writes the current camera settings to the corresponding memory page in the EEPROM.

Page 1, shown in Figure 21, is the power-up default page. Page 0 is the factory default. To save your current camera settings for power up default, write the settings to memory page 1.

Figure 21. Memory Pages



To reset memory page 1 to the factory default settings, load memory page 0 and save those settings to memory page 1. Page 0 is password-protected and you cannot write to it. If you find that you do need to write to page 0, contact JAI PULNiX for password access.

Note: Configurations such as grabber settings, pulse generator, GPIO, and image setting must be saved into the XML file. Refer to Section 3.4.1, “Check the Current Camera Setting,” on page 12 for more information.

3.4.9 Free-Running Mode

The camera must be in “Manual Shutter” or “Direct Shutter” mode. In the example below, there is no partial scan.

1. Connect to the camera.
2. Under the “Device Features” tab, set the GPIO look-up table to Q5=1.
3. Under the “GigE Software” tab, change the manual shutter or direct shutter values.
4. Click **Start**.

You should now see a free-running video stream.

3.4.10 Externally Triggered

The external trigger is sent through pin 6 of the 12-pin Hirose connector. To use the software to enable the external trigger, use the following steps:

1. Change the GigE camera software shutter mode to Async. Shutter.
2. Set the GPIO look-up table to Q4 = I0 and Q5 = 1.

3.4.11 Internally Triggered

The camera-control software includes pulse generators that you can use to trigger the camera internally. To do this, use the following steps:

1. Select “Pulse Generator 0” under the “Device Features” tab. Set the pulse width and delay and check the “Periodic” option if needed.
2. Set the GPIO look-up table to Q5=1 and Q4=I7.
3. Set the shutter mode in the GigE camera software page to async shutter. For more information, refer to Section , “Mode,” on page 14.

3.4.12 Save/Restore Settings to Your Hard Disk

To save your current settings into the XML file, go to the main menu, select “File” and click **Save As**. The XML file saves all your configurations, such as grabber settings, pulse generator, GPIO and language settings.

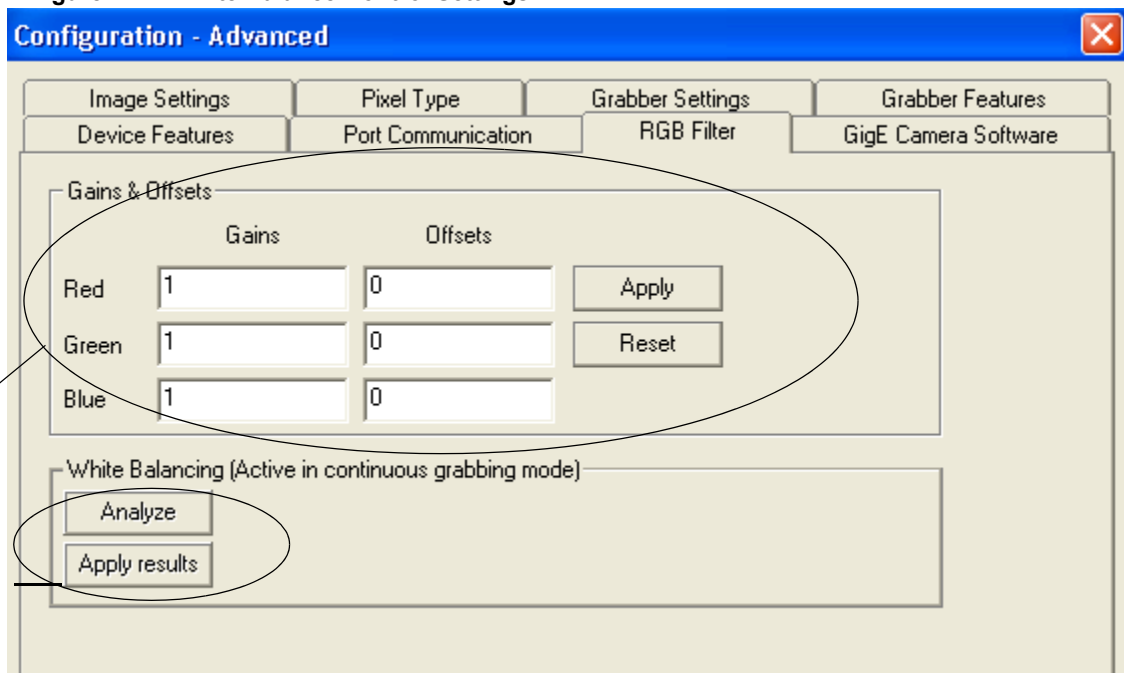
The XML file will not, however, save camera parameters such as shutter mode, shutter speed, gain settings, offset level, scan mode, and LUT. For more information about saving these camera parameters, refer to Section 3.4.8, “Memory Pages,” on page 16.

3.4.13 White Balance Control (Color Versions Only)

To determine white balance, use the following steps:

1. Select full scan mode in the GigE Camera Software tabbed dialog. shown in Figure 22.
2. Start the live video by clicking **Start** in the Acquisition tabbed dialog box of the main frame.
3. Select the RGB filter tab. Show the camera a piece of white paper to make sure that the image is not saturated.
4. Click **Analyze** to automatically calculate the white balance.
5. Once white balance has been calculated, click **Apply Results** to apply white balance. You can also assign custom gain and offset values to the R, G, and B channels. If you choose to assign custom values, click **Apply Results**.

Figure 22. White Balance Control Settings



3.4.14 Main Menu: *Option*

The Grabber Settings tabbed dialog box has a check box to enable the test pattern that is internally generated by the integrated camera software.

3.4.15 Version

You can view the version number of the Cam2Net camera interface application by clicking **Help--> About.** The version number of the integrated GigE camera software appears in a text box control called "Version" in the GigE Camera tabbed dialog box.

3.4.16 Exit

From the main menu, select "File," and click "Exit" to exit the software.

4 Signal Handling

This section describes the signal handling of the GE cameras in the following section:

- "Camera Inputs" on page 19
- "GPIO Control Block" on page 20
- "GPIO Look-Up Table" on page 20
- "GPIO Label Tables" on page 22
- "Pulse Generators" on page 24

Refer to the *Cam2Net User's Manual* for additional details.

4.1 Camera Inputs

For information on the polarity and type of the signals required to support specific camera functions, refer to "Asynchronous Reset" on page 39

The TM-1405GE has three externally controllable standard signals:

- Trigger (VINIT or EXT_TRIG) (CC1 equivalent)
- VD in (EXT_VD) (CC3 equivalent)
- HD in (EXT_HD) (CC4 equivalent)

The labels for these signals in the GPIO Control Block programming language are:

- I0, for VINIT (must be configured as EXT_TRIG)
- I1, for VD in (must be configured as EXT_VD)
- I2, for HD in (must be configured as EXT_HD)

4.2 Camera Outputs

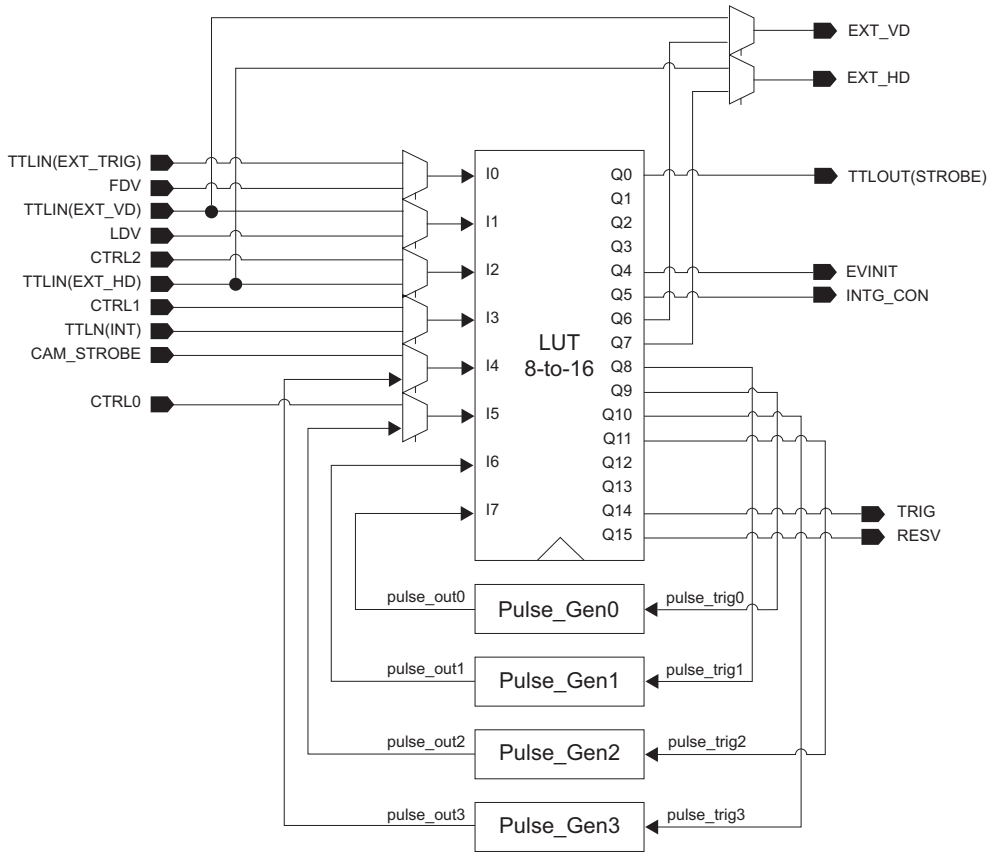
When the Asynchronous Trigger is used, the strobe output indicates the exposure period.

- I4 for strobe output (must be configured as CAM_STROBE)

4.3 GPIO Control Block

Figure 23 below shows the GPIO Control Block signals for the GE Cameras.

Figure 23. GE Camera GPIO Control Block



Inputs I0 through I7 can be either external or internal inputs to the look-up table. The outputs are used by the imager part of the GE camera.

The HD and VD signals can be passed through, bypassing the GPIO lookup table. Figure 25 on page 21 shows a screen dump of the GPIO configuration page, where HD/VD bypass selection can be made. The default value 0 (zero) is through the lookup table. Value 1 (one) is bypassing the lookup table.

The SDK and the Cam2Net Camera Interface Application both supply methods to select GPIO bypass of the external VD and HD (I1 and I2).

You can select which signal source to lead to the GPIO inputs. This is done in the GPIO look-up table page as shown in Figure 24 on the following page.

Figure 24. GPIO Look-Up Table

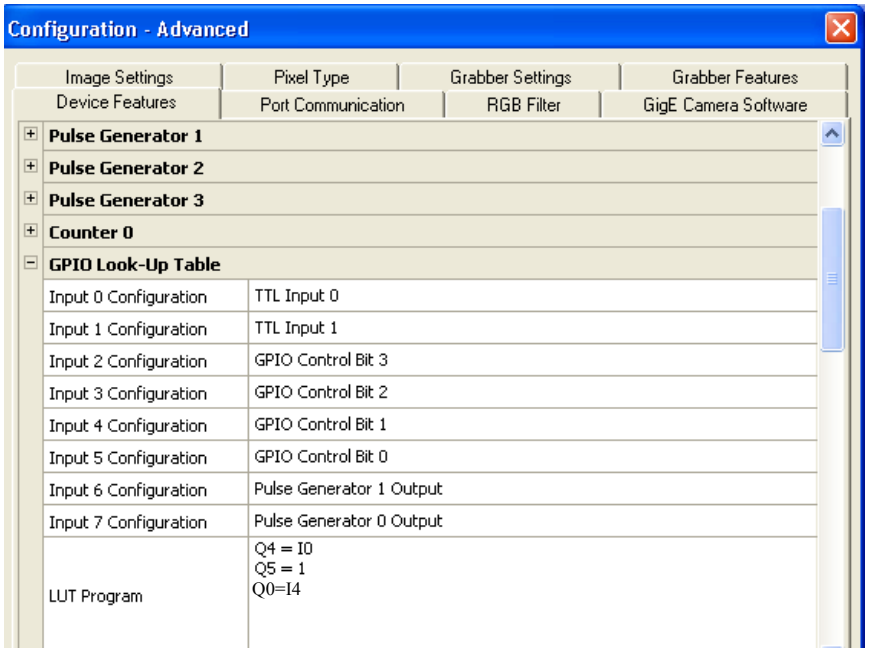
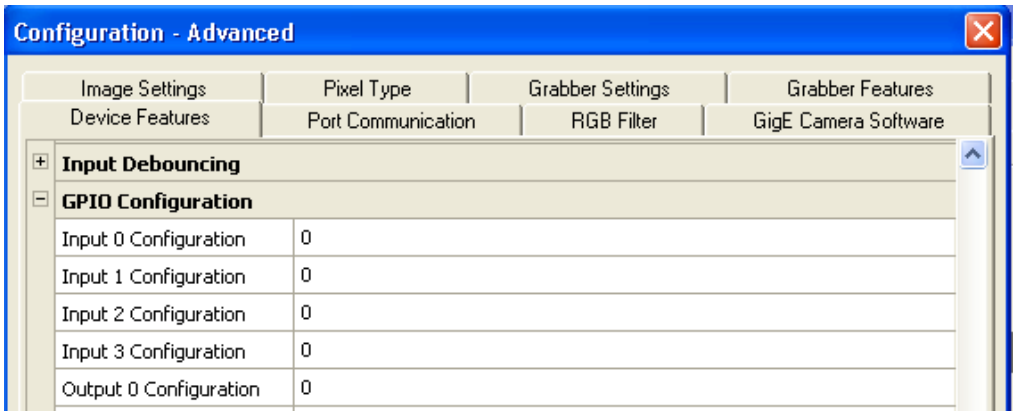


Figure 25. The GPIO Configuration



4.4 GPIO Label Tables

Table 2 shows which GPIO inputs carry the different signals. The top line for each label contains the default signal.

Table 2. GPIO Look-Up Table Input Labels

Input Label	Signal	Description
I0	TTL_IN(EXT_TRIG)	TTL-input 0. Used for external trigger.
	FDV	Internal signal. Frame Data Valid.
I1	TTL_IN(EXT_VD)	TTL-input 1. Used for external vertical drive.
	LDV	Internal signal. Line Data Valid.
I2	CTRL2	Internal control signal.
	TTL_IN(EXT_HD)	TTL-input 2. Used for external horizontal drive.
I3	CTRL1	Internal control signal.
	TTL_IN(INT)	TTL-input 3. Used for external integration control.
I4	CAM_STROBE	Internal signal. Strobe Input.
	PULSE_GEN3	Pulse Generator 3 signals go here.
I5	CTRL0	Internal control signal.
	PULSE_GEN2	Pulse Generator 2 signals go here.
I6	PULSE_GEN1	Pulse Generator 1 signals go here.
	N/A	
I7	PULSE_GEN0	Pulse Generator 0 signals go here.
	N/A	

Table 3 shows which output labels carry the output signals.

Table 3. GPIO Look-Up Table Output Labels

Output label	Signal	Description
Q0	TTL-OUT(STROBE)	Strobe output
Q1	N/A	
Q2	N/A	
Q3	N/A	
Q4	EVINIT	Trigger
Q5	N/A	
Q6	EXT_VD	Vertical Drive
Q7	EXT_HD	Horizontal Drive
Q8	pulse_trig1	Pulse Generator 1 gets its trigger here
Q9	pulse_trig0	Pulse Generator 0 gets its trigger here
Q10	pulse_trig3	Pulse Generator 3 gets its trigger here
Q11	pulse_trig2	Pulse Generator 2 gets its trigger here
Q12	N/A	
Q13	N/A	
Q14	TRIG	Trigger for camera's internal frame grabber
Q15	RESV	Reserved

4.5 Pulse Generators

The TM-1405GE camera has four independently programmable pulse generators. These generators can run as either periodic or triggered. To run the pulse generators as triggered, they can be triggered on either levels or signal edges. These generators can be tied to the camera inputs (camera-control lines). For example, you can set pulse generator 0 in the Device Features tabbed dialog box to the following values:

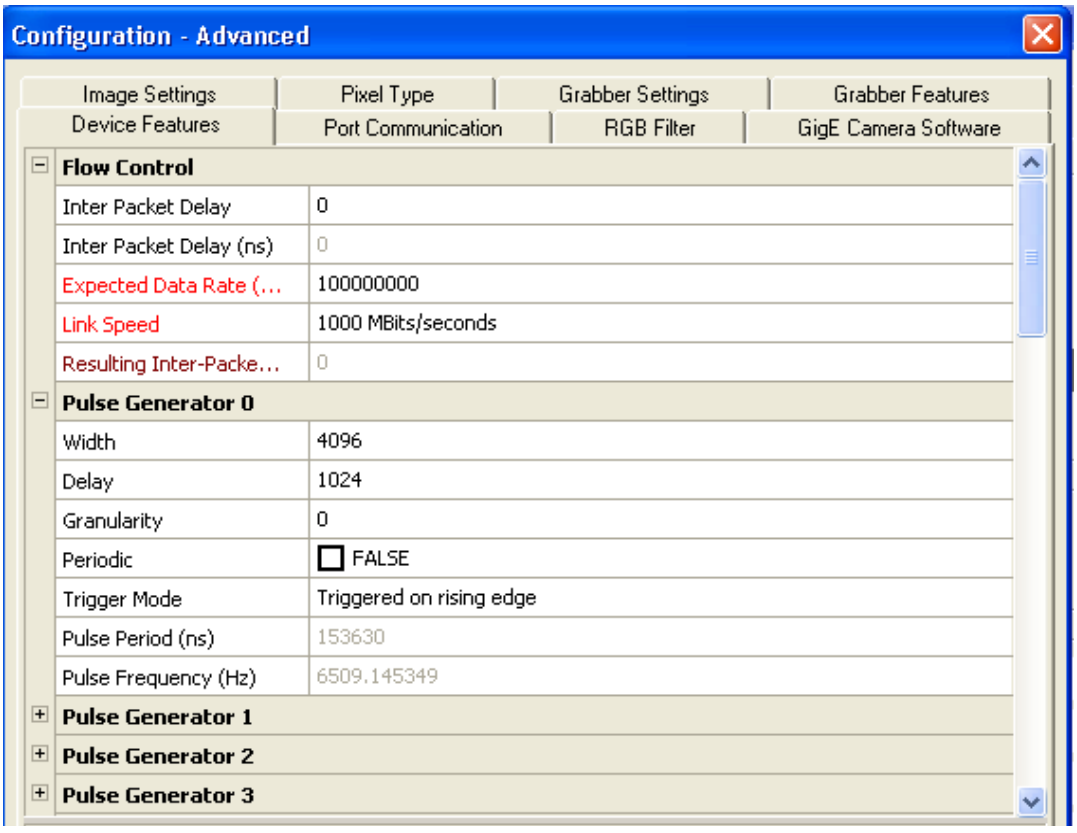
- Delay = 600
- Width = 14,000
- Granularity = 1

Now check the Periodic option and change the camera settings to Async 9. This triggers the camera, based on the pulse width set in the Pulse Generator page.

Be careful with the pulse generator's GPIO input and output polarity. If the delay and pulse-width duration are switched around, the output polarity must be negated in the GPIO lookup table.

The pulse generators are configured in the "Pulse Generator" section in the "Device Features" tab of the Advanced Configuration window as shown in Figure 26.

Figure 26. Pulse Generator Page



5 GigE Series Camera Serial Commands

You can control the GigE series cameras by serial command either using RS-232 or Camera Link. The Start character is always ":" and the End character is always <CR> (return). For example, to set Asynchronous Pulse Width Mode, send the command :ASH=9<CR> to the camera. Table 4 lists serial commands you can use to control the camera.

Table 4. TM-1405GE Command List

Command	Parameters	End of Command	Ack Response	Description
Gain, Vtop, Vbottom, and Vab				
:MGA=	XXX	<cr>	:o<cr>	Set CDS gain (XXX = 047 - 0E7)
:VTP=	XXX	<cr>	:o<cr>	Set VTOP (XXX = 000 - 0FF)
:VBT=	XXX	<cr>	:o<cr>	Set VBOTTOM (XXX = 000 - 0FF)
Shutter Mode and Shutter Speed				
:MSH=	X	<cr>	:o<cr>	Set Manual Shutter (X = 0 manual, no shutter)
:ASH=	X	<cr>	:o<cr>	Set Async Shutter (X=0 async no shutter, X=9 PWC)
:DSH=	X	<cr>	:o<cr>	Set Manual Direct Shutter (1-1052)
:ADS=	XXX	<cr>	:0<cr>	Set Async Direct Shutter (DDD=000-81F)
Data Output Control				
:VDO	S	<cr>	:o<cr>	Video Data Output Order (s = A, B, C)
:DDP=	N	<cr>	:o<cr>	Set output data depth (N = 0 : 8 bit, N = 1 : 10 bit)
Auto Black Level Control				
:EAOC	XXX	<cr>	:o<cr>	Set Auto Black Level (XXX = H'000 - H'OFF)
:DAOC				Disable Auto Black Level

Table 4. TM-1405GE Command List (Continued)

Command	Parameters	End of Command	Ack Response	Description
Lookup Table				
:LINR		<cr>	:o<cr>	Set linear table
:GM45		<cr>	:o<cr>	Set gamma .45 table
:KNEE=	X1Y1X2Y2	<cr>	:o<cr>	Set knees (X1, Y1, X2, Y2 = 00 - FF)
:NLUT	X	<cr>	:o<cr>	Set positive knee or negative knee (X=0 positive, X=1 negative)
EEPROM				
:WRPG	X	<cr>	:o<cr>	Write Page X = 0 - 6; (Page 0 is factory setting, Page 1 is power up default setting)
:LDPG	X	<cr>	:o<cr>	Load Page (X = 0 - 6)
:RDPG	X	<cr>	:o[settings]<cr>	Read Page (X = 0 - 6)
:RPST		<cr>	:o[settings]<cr>	Report current settings
Scan Mode				
:SMDA		<cr>	:o<cr>	Set Full Scan Mode
:SMDU=	XXXXYYYY	<cr>	:o<cr>	Set User Scan Area (XXXXX=0000 - 040F, YYYY=0001 - 0410
Miscellaneous				
:DDP	X	<cr>	:o<cr>	Set output data depth (X=0 8bit, X=1 10bit)
:TAH=	X	<cr>	:o<cr>	External Trigger Polarity (X=1 Active High, X=0 Active Low)
:TPTN	X	<cr>	:o<cr>	Enable/Disable Test Pattern (X = 1Enable, X = 0 Disable)
:CAM?		<cr>	:o[model]<cr>	Enquire Camera Model
:VER?		<cr>	:o[version]<cr>	Enquire MPU firmware version

Note: If a command is not accepted for any reason, the camera returns a Nack response ":e"<cr>

Report Command: RPST<cr>

TS Return : O RR + "24 bytes" + <cr>

Table 5. 18 Bytes Status Report

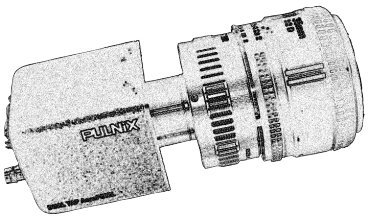
Byte 1, 2	MGA		Gain Control (H'047 - H'0E7)
Byte 3, 4	VTOP		VTOP (H'000 - H'0FF)
Byte 5, 6	VBTM		VBOTTOM (H'000 - H'0FF)
Byte 7, 8	EAOC	Auto Black Level	EAOC (H'000 - H'0FF)
Byte 9	Function Flag 0		
	Bit 7	output pixel order 1	"00"=<-- "10"=<-- "01"=<--
	Bit 6	output pixel order 0	
	Bit 5 Bit 4		
	Bit 3 Bit 2		
	Bit 1 Bit 0	Scan Mode	Full/Partial Scan
Byte 10	Function Flag 1		
	Bit 7	ShutterMode2	"000"=Manual Shutter "001"=Async Shutter "010"=Async Direct Shutter "011"=Direct Shutter
	Bit 6	ShutterMode1	
	Bit 5	ShutterMode0	
	Bit 4	Output Data Depth 0=8 bit	0=8bit; 1=10bit
	Bit 3		
	Bit 2		
	Bit 1		
	Bit 0		
Byte 11	Function Flag 2		
	Bit 7	LUTSIGN	0=Positive LUT; 1=Negative LUT
	Bit 6		
	Bit 5		
	Bit 4		
	Bit 3		
	Bit 2	LUTTABLE2	"000"=Linear LUT "001"=Gamma.45 LUT "010"=Two Knee Table
	Bit 1	LUTTABLE1	
	Bit 0	LUTTABLE0	
Byte 12	Function Flag 3		

Table 5. 18 Bytes Status Report (Continued)

	Bit 7	TESTPATTERN	0=Disable TP; 1=Enable TP
	Bit 6	PASSWORD	0=Disable PW; 1=Enable PW
	Bit 5		
	Bit 4		
	Bit 3	Auto Black Level	0 = Disable; 1 = Enable
	Bit 2		
	Bit 1		
	Bit 0		
Byte 13	X1		(X1, Y1) Coordinate for Knee 1 (X1, Y1 = H'00 - H'FF)
Byte 14	Y1		
Byte 15	X2		(X2, Y2) Coordinate for Knee 1 (X2, Y2 = H'00 - H'FF)
Byte 16	Y2		
Byte 17	User Scan		Start Point of User Scan Area
Byte 18	Active Line of Scan		Active Line of User Scan Area
Byte 19	Direct Shutter		H'000 - H'40F
Byte 20			
Byte 21, 22			
Byte 23, 24	Reserved	Total line number	H'040 - H'1F3

TM-1405GE Hardware

Operation Manual



6 Hardware Introduction

This chapter contains the following sections:

- "Product Description" on page 29
- "Features" on page 30

6.1 Product Description

The JAI PULNiX TM-1405GE is a high-speed progressive scan CCD camera. The interline-type CCD permits full vertical and horizontal resolution of very high speed shutter images and applications. The electronic shutter, which has speeds to 1/16,000 second., can be reset asynchronously by external pulse control. The frame rate for a full image is 30 fps, with partial scan mode of up to 1 line. A 2:1 ratio imager format with uniform square pixels provides superior image definition in any orientation.

The TM-1405GE has a full dynamic range control function, which can be set at externally selectable look-up table (LUT) knee slopes to convert 10-bit input to 8-bit output, thereby optimizing the CCD's full dynamic range in the normal output signal range.

Applications for the TM-1405GE include machine vision, medical imaging, intelligent transportation systems, high-definition graphics, on-line inspection, gauging, character reading, archiving, and high-security surveillance.

The TM-1405GE series consists of the TM-1405GE (monochrome) and the TMC-1405GE (color). Unless otherwise noted, all information contained in this manual is relevant to both models.

6.2 Features

The TM-1405GE has the following features:

- Miniature size and light weight

  The printed circuit boards in the TM-1405GE have been arranged to create modular electronics, giving the camera flexibility. In addition, the use of miniature solid-state components results in a compact, lightweight camera that is 50.8mm x 50.8mm x 83.5mm in dimensions, and weighs only 212 grams.

- Imager

  The TM-1405GE uses a progressive scan interline transfer CCD that has the following features:

  - Resolution of 1392 x 1040 active pixels for excellent image quality.
  - 4.65 x 4.65 µm square pixels for precise dimensional measurement.
  - High-speed electronic shutter capability for high dynamic resolution of moving objects that eliminates the need for a mechanical shutter.
  - Progressive scan CCD eliminates interlace deterioration of image and increases ease of computer interface.
  - High sensitivity and low noise at fast scanning. The CCD has an excellent S/N ratio at the default setting greater than 51dB.

- Electronic shutter

  The TM-1405GE has a substrate drain-type shutter mechanism which provides superb pictures at various speeds without smearing. For more information, refer to Section 8.3, “Electronic Shutter,” on page 41.

- Asynchronous reset

  The TM-1405GE captures asynchronous reset images and provides single-shot video output with single FDV. This makes it simpler for an ordinary frame grabber to capture the asynchronous reset images. The TM-1405GE’s asynchronous reset is flexible and accepts external horizontal drive (HD) for phase locking. When the VINIT (5V) pulse is applied to CC1, it resets the camera's scanning and purging of the CCD.

  The TM-1405GE has three modes to control the asynchronous reset and shutter speed:

  - **Async, no shutter.** The video signal and FDV are reset by external VINIT.
  - **Async direct shutter.** The shutter speed control depends on the number of horizontal lines controlled through the serial commands.
  - **External VINIT with pulse width**. The duration between pulse edges controls the shutter speed externally.

- Output

  The TM-1405GE has a 10-bit/8-bit Gigabit Ethernet output. The analog output is 714 mVp-p composite video (75 ohms) on all models.

- Warranty

  Contact your factory representative for details about the warranty.

7 Installation

The following instructions will help you to set up your camera quickly and easily. JAI PULNiX suggests that you read through these instructions first, before you unpack and set up your camera system.

7.1 Getting Started

7.1.1 Unpacking Instructions

JAI PULNiX recommends that you save the original packing cartons for the cameras and accessories in case you need to return or exchange an item.

We also recommend that you bench-test any equipment being sent to another location for field installation to assure that everything is fully operational as a system.

7.1.2 Components

When you receive your TM-1405GE camera from JAI PULNiX, the contents of the shipping box should include the camera and a document download card. If either of these items are missing, contact your JAI PULNiX representative immediately. The document download card includes instructions and web locations for downloading the datasheet, manual, and camera-control software. If you do not have Internet access, contact JAI PULNiX to receive this material on a CD-ROM.

7.1.3 Accessories and Options

The following additional accessories and options may be required for your application:

- PD-12U series power supply
- 12P-02S power cable
- Cat5e or cat6 shielded Ethernet cable (not supplied by JAI PULNiX)

Check with your JAI PULNiX representative before you install your camera to determine what you might need.

7.2 Camera Setup

7.2.1 Heat Dissipation

The TM-1405GE is a compact camera. Since all the electronics have been packed in a compact package, the outer case of the camera can become hot because of heat dissipation. For optimal performance, JAI PULNiX recommends using a cooling fan to set up a positive air flow around the camera and following the precautions below.

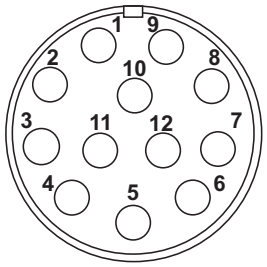
- Mount the camera on a large heat sink (camera bracket) made out of a heat-conductive material like aluminum.
- Make sure the flow of heat from the camera case to the bracket is not blocked by a non-conductive material like plastic.
- Make sure the camera has enough open space around it to facilitate the free flow of air.

Contact JAI PULNiX. at (800) 445-5444 or send an E-mail to imaging@jaipulnix.com if you have any questions.

7.2.2 Connector Pin Configurations

The TM-1405GE has a 12-pin Hirose connector for power input and signal integration as shown in Figure 27.

Figure 27. 12-Pin Connector Pinouts



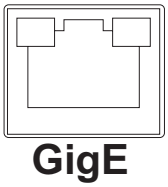
Pin #1 is Ground and pin #2 is +12V DC. Table 6 shows the pin-out table.

Table 6. 12-Pin Connector

Pin	Description	Pin	Description
1	GND	7	VD in
2	+12V DC	8	Strobe
3	GND (analog)	9	HD in
4	Video out	10	Reserved
5	GND (digital)	11	Reserved
6	VINIT in	12	Reserved

The GigE socket, marked on the camera's back panel as "GigE," is a standard RJ-45 Ethernet socket as shown in Figure 28.

Figure 28. GigE Ethernet Connector



Use at least cat5e UTP cables (cat6 cables are preferred). Refer to the *Cam2Net User's Manual* for details. JAI PULNIX recommends the use of shielded cables to reduce emissions and for CE/FCC compliance. Double-shielded cables further reduce emissions.

7.2.3 Power Supplies and Power Cable Setup

Power Supplies

The TM-1405GE camera requires 12V DC power obtained through the 12-pin connector located on the rear panel of the camera. JAI PULNiX recommends the following power supplies:

PD-12UU	100-240V AC/12V DC	1.2A universal voltage power supply, US Plug
PD-12UUP	PD-12UU with12-pin connector	US plug
PD-12UE	PD-12UU	European plug
PD-12UEP	PD-12UU with 12-pin connector	European plug

If you are providing power through the 12-pin connector, the PD-12P, PD-12UEP and PD-12UUP power supplies are available with the 12-pin mating connector already attached to the leads from the power supply. You can connect the PD-12UU and PD-12UE power supplies to the JAI PULNiX power cable using a terminal strip or directly.

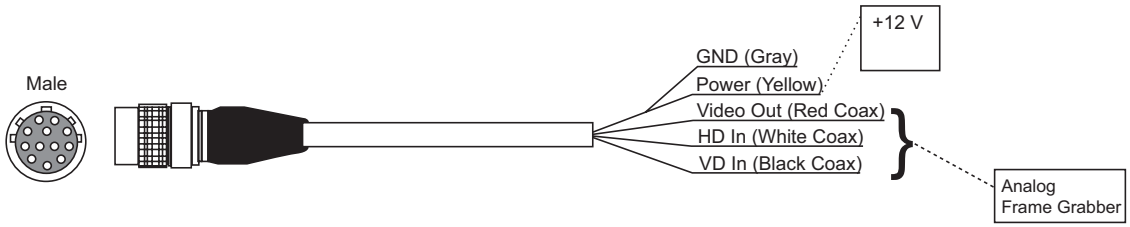
When wiring the PD-12UU and PD-12UE power supplies directly, note the following:

- Twist the lead ends together and tin-soldered for strength and electrical continuity.
- Use shrink tubing or a similar insulator to prevent exposed leads from touching and shorting.
- The +12V lead is marked with a red stripe or white lettering; be sure not to reverse the leads.
- Make sure all connections are properly insulated to prevent shorting.

JAI PULNiX Power Cables

If you are using JAI PULNiX power cables, such as the 12P-02S, refer to the Figure 29 which shows the cable pin-out diagram and pinouts. The color-coded leads use Gray for Ground and Yellow for +12V.

Figure 29. 12P-02S Interface Cable (optional)



12P-02S Interface Cable					
Pin#	**Lead Color**	**Function**	**Pin#**	**Lead Color**	**Function**
1	Gray	GND	7	Black coax	TTL IN (EXT_VD)
2	Yellow	+12V DC	8	White coax shield	TTL OUT (STROBE)
3	Red coax shield	AGND	9	White coax	TTL IN (EXT_HD)
4	Red coax	VIDEO	10	Brown	RESV
5	Orange coax shield	GND	11	Blue	RESV
6	Orange coax	TTL IN (EXT_TRIG)	12	Black coax shield	RESV

Note: Make sure that the unused leads are not touching and that there is no possibility that exposed wires could cause the leads to short.

Building Your Own Power Cable

Refer to the 12-pin connector pin-out in Figure 29 on page 34. Connect the Ground lead to pin #1, and the +12V DC lead to pin #2 of the 12-pin connector. Power must be DC-regulated, and of sufficient current to properly power the camera.

Attaching the Power Cable to the Connector

The 12-pin connector is keyed and will only fit in one orientation. To properly attach the power cable to the camera connector, use the following steps:

1. Rotate the connector while applying slight pressure until the keyways line up.
2. Press the connector into place until firmly seated.
3. Plug the power cord into the 100V AC socket. This powers up the camera.

7.2.4 Attaching the Camera Lens

The TM-1405GE camera accepts 1/2” or larger format size C-mount lenses. To attach the C-mount lens[1] to the camera, carefully engage the threads and rotate the lens clockwise until it firmly seats on the mounting ring. Do not force the lens if it does not seat properly.

Note: Some lenses with extremely long flangebacks may exceed the mounting depth of the camera.

7.2.5 Adjustable Back-Focus

Before cameras are shipped,back focus is carefully set using a collimator, oscilliscope and other specialized equipment. While the factory-set focus serves well in most cases, an adjustable back focus makes it possible to improve image sharpness when using lower-cost zoom lenses, custom optics, or in unusual parameters.

There should be an obvious need to refocus the lens before attempting to change the back focus. This is a very exacting task. Some cameras have been returned to the factory to reset the back focus after failed attempts to change the focus by customers. It might be wise to label cameras whose back focus was adjusted

1. The camera must be connected to a monitor before attempting to adjust the back focus.
2. To back focus the camera, first attach a C-mount lens in the mount. Be certain that the lens is properly seated.
3. Next set the lens focus to infinity (if the lens is a manual iris, set the iris to a high f number while still retaining a well illuminated image).
4. Loosen the three miniature hex set-screws (use a 0.9 mm hex wrench) that lock the focus ring in place (two screws for a CS-mount). Slowly turn the lens and focus ring assembly back and forth until you obtain the best image of the desired object. This sets the back focus. Once the best image is obtained, tighten the focus ring set-screws until they are snug. Do not over-tighten the screws.

Note: Mini-bayonet cameras adapted to C-mount do not have the back focus feature.

1. C-mount to F-mount and C-mount to K-mount adapters are available for larger format lenses (35mm). Check with local photography dealers for these lens adapters.

Figure 30. Back-Focus Set-Screw Locations

Loosen the three 2mm screws around the perimeter of the C-mount lens collar (two 2mm screws for a CS-mount) to adjust the back focus. Unless you absolutely must, do not attempt to adjust this focus.

8 Operation

This chapter contains information about performing operational procedures. It contains the following sections:

- “Progressive Scanning” on page 37
- “Bayer Color Filter (Color Versions)” on page 38
- “Electronic Shutter” on page 41
- “External Sync” on page 42
- “Asynchronous Reset” on page 42
- “Programmable Look-Up Table (LUT) and Knee Control” on page 45
- “Camera Timing Charts” on page 46
- “Video Output” on page 48
- “External HD Locking and External VD Reset” on page 49
- “Asynchronous Reset” on page 49

8.1 Progressive Scanning

Standard TV-system scanning is 525 lines interlace scanning as specified in the RS-170 protocol. Every other horizontal line (odd lines and even lines) is scanned at a 60Hz rate per field, and the scanning is completed with two fields (one frame) at 30Hz rate. Because of the interlace scanning, the vertical resolution of CCD cameras is limited at 350 TV lines, regardless of the horizontal resolution. When electronic shutter is applied, the CCD can hold only one field of charge at each exposure. This means that the vertical resolution of the electronic shutter camera is only 244 TV lines. The situation is the same for an HDTV-format camera, since it has interlaced scanning and the vertical resolution of the shuttered image is 500 lines.

The TM-1405GE uses a state-of-the-art progressive scanning interline transfer CCD which scans all lines sequentially from top to bottom at one frame rate. Like a non-interlace computer screen, it generates a stable, crisp image without alternating lines and provides full vertical TV resolution of 1040 lines.

The interline transfer architecture is also important to generate simultaneous shuttering. This is different from full frame transfer architecture, which requires a mechanical shutter or strobe light in order to freeze the object motion.

The TM-1405GE outputs the progressive scanned image with an electronic shutter in two different formats.

- Progressive scanning digital - The CCD signal goes through A/D converters 10-bit in, 10-bit/8-bit out. The digital output is available using the Gigabit Ethernet connector.
- Analog output - The analog output is the same as 75 ohms, 714mV format available from BNC and
  12-pin connector.

8.2 Bayer Color Filter (Color Versions)

JAI PULNiX AccuPiXEL series color cameras are high-resolution, high-speed progressive scan CCD cameras. The interline transfer, progressive scan CCD permits full vertical and horizontal resolution of images acquired at very high shutter speeds. The electronic shutter, which has speeds to 1/16,000 sec., can be reset asynchronously by external pulse control. Uniform square pixels provide superior image definition in any orientation. On-chip micro lenses mean increased sensitivity.

8.2.1 Color Filter Array

JAI PULNiX AccuPiXEL cameras use Bayer CFA (color filter array) as their standard primary color filter. This filter provides the most popular color interpolation supported by numerous software suppliers.

The digital format allows the camera to output accurate pixel data, including the color information. When the data is stored in the frame buffer of a frame grabber or computer, the color information is easily manipulated to restore the original color images. Because the color filter array contains only a single R, G or B color in each pixel, the restored image has to fill in colors in the missing pixel locations. The software uses neighboring pixel information to “guess” the missing colors to make smooth, clear images. This is called “color interpolation.” Today’s high-speed computers allow such color interpolation to be done almost in real time. Because these cameras do not contain internal color-processing circuitry, they are smaller and less expensive than full-function color cameras.

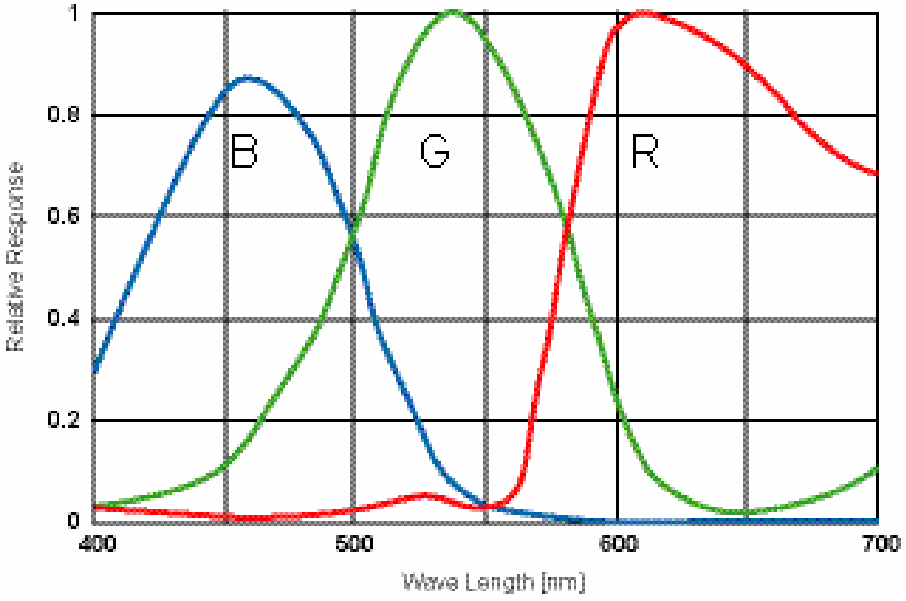
8.2.2 Bayer Color Filter Array (CFA)

The Bayer CFA is an R, G, B primary color filter array. This is the most widely accepted CFA for the single-chip CCD progressive scan format. This type of array layout has a specific order for each color’s pixels. Since the human eye’s resolution and color recognition are highest at green, the CFA contains two greens per each red and blue.

It is critical for the frame grabber and color interpolation to know where the individual color pixels exist relative to sync (LDV and FDV) timing.

This requirement makes digital output the preferred choice, because the timing relationships are very accurate

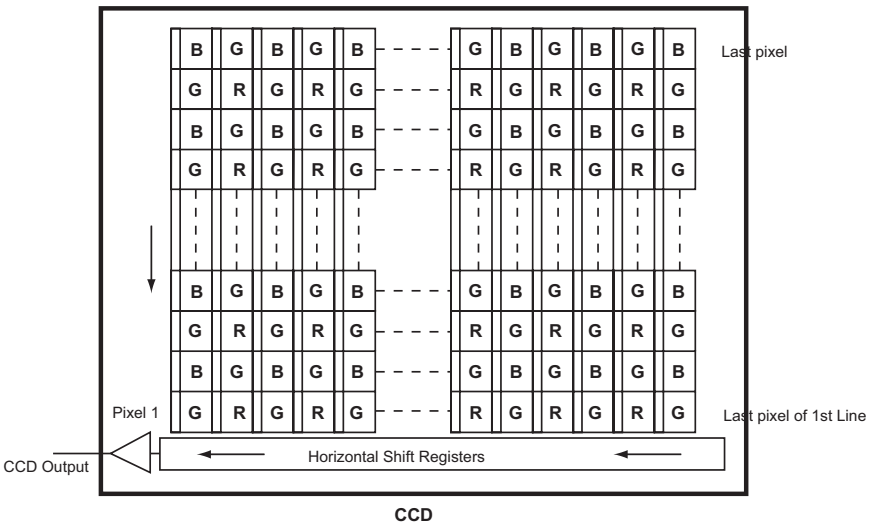
Figure 31. Bayer Spectral Response.



8.2.3 Starting Pixel Configuration

All manufacturers produce identical Bayer CFAs, but there are slight differences between the CCDs produced by different manufacturers. The first line is generally R and G. The camera timing can be adjusted to start with either G or R by skipping the very first pixels at each lines. The majority of color interpolation software can select between a variety of pixel relations, such as R/G start or G/R start, as well as G/B start and B/G start. Once the correct scanning is configured, the rest of the interpolation will be exactly the same. Please contact JAI PULNiX for further information regarding CCD manufacturers.

Figure 32. Example of Color CCD CFA Pattern



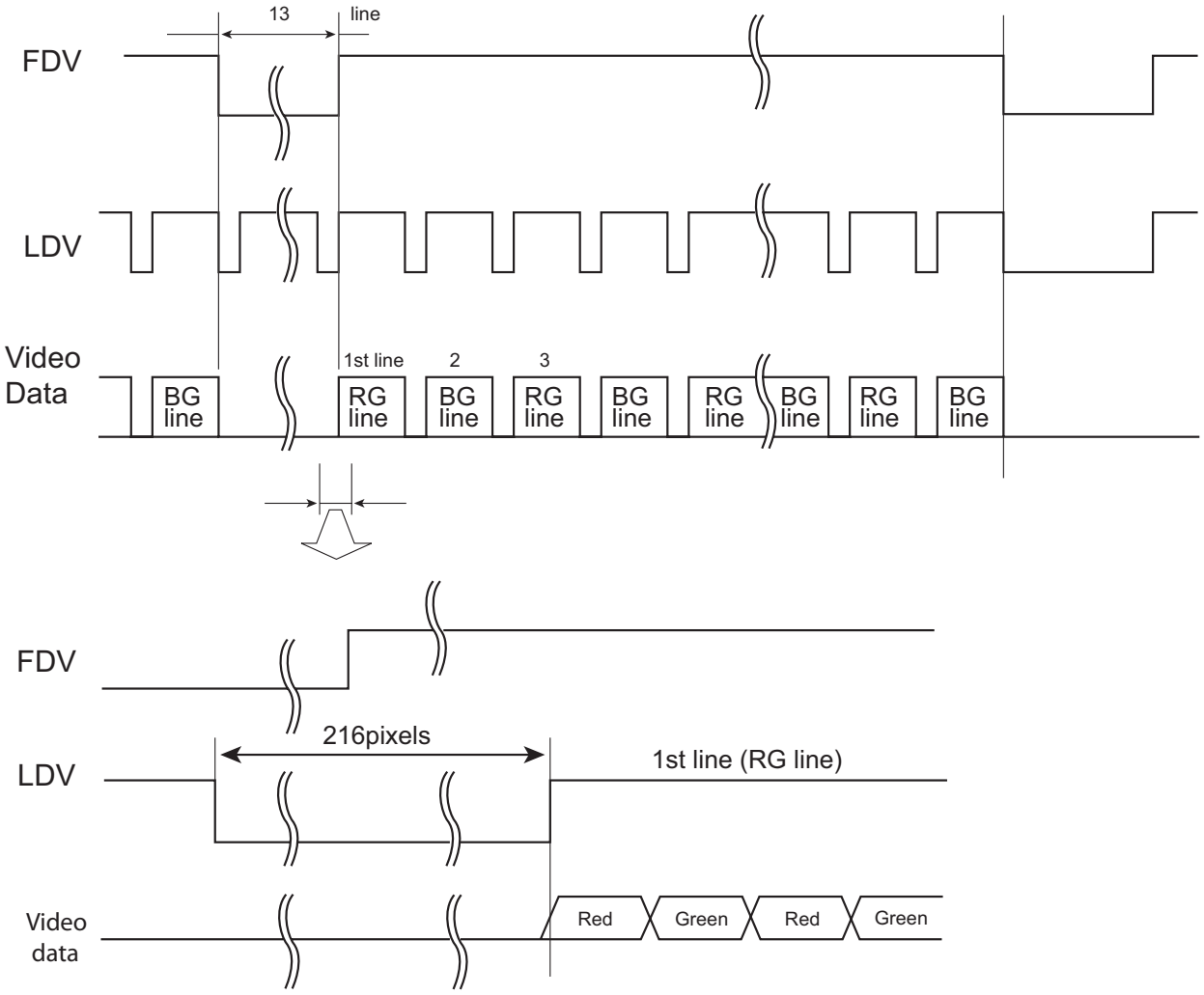
8.2.4 Sync and Data

The individual color data is exactly the same as the pixel data. This means that the timing relationships of the color cameras are also the same as of the B/W cameras.

For a detailed timing chart, please refer to each B/W camera's data sheet and manual.

The following diagram is an example of the TMC-4100GE default mode. FDV and LDV are used internally for the GigE interface.

Figure 33. Example of TMC-4100GE (Same as TM-4100GE)



8.2.5 Camera Functions

AccuPiXEL color cameras perform all functions the same way as B/W cameras. However, because of color characteristics, the LUT (Look-up Table) is different. The LUT is a powerful tool to adjust the dynamic range as well as color dynamic range. Since human color perception is non-linear, LUT

selection can help optimize color contrast by selecting the LUT value. Gamma 0.45 is logarithmic and is closed to human perception.

When LUT is selected, black-level adjustment must be more accurate than for B/W cameras.

For a detailed timing chart, please refer to the standard AccuPiXEL camera data sheet, or contact JAI PULNiX.

8.2.6 Interpolation Software

The color interpolation can be performed in the frame grabber or by using the host computer's CPU. Most major frame grabbers with processing capability provide tools for color interpolation. Software vision packages also provide color interpolation capability, but speed and performance may be determined by the PC's resources and by the complexity of the interpolation routine.

8.2.7 Color Interpolation

The Bayer pattern color filter array (CFA) consists of R, G, and B primary colors. Each pixel represents one of three colors. In order to display or print color images, the signal has to be converted to RGB output, which has three independent channels (outputs) and sync signals.

Color interpolation software or firmware performs the color preprocessing by filling the missing color pixels with neighboring pixels. It then separates the stream of data, (8-bit or 10-bit) into 3 (RGB) data (8-bit x 3) and adds the color matrix to adjust and balance each of the R,G, and B channels (white balance or color balance).

Green	Red	Green
Blue	Green	Blue
Green	Red	Green

The image quality depends on the camera's own pixel data (including pixel data independency from neighboring pixels, noise and color filter), and interpolation of the software algorithm such as 3 x 3 interpolation, 2 x 2 interpolation, color matrix, white balance capability, etc.

All AccuPiXEL color cameras are carefully designed for maximum color performance. JAI PULNiX strongly suggests that you use digital output for the best performance.

Some software is used on board (FPGA or DSP) to perform the interpolation. Other software simply uses the host computer's memory and CPU. The process speed may vary depending on the architecture and speed of the computer.

8.3 Electronic Shutter

The TM-1405GE has a substrate drain-type shutter mechanism which provides a superb picture at various speeds without smearing. A built-in flexible shutter speed control selects the electronic shutter rate from 1/30 to 1/21,000.

With VINIT high (CC1), the CCD keeps discharging. With an active low pulse to VINIT, the camera resets and purges the charge momentarily. Then it starts integrating for the period of shutter control set by either an external pulse width or internal shutter control. Progressive scanning permits a full 1040

lines of vertical resolution, as compared to a conventional CCD camera which captures only half the vertical lines per shutter.

8.4 External Sync

The TM-1405GE accepts an external synchronization of standard HD and VD on CC3 and CC4 of the Gigabit Ethernet connector for general locking to an external source. The tolerance is ±2% horizontal frequency.

8.5 Asynchronous Reset

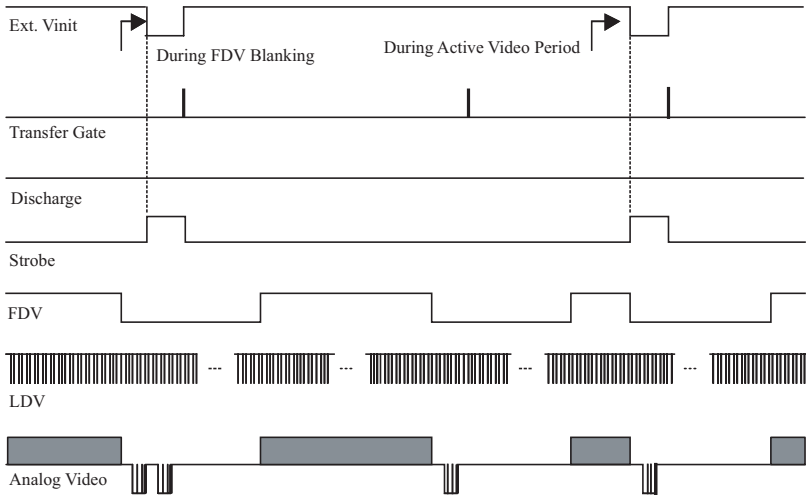
The TM-1405GE camera includes the following modes to control the asynchronous reset and shutter speed:

- Async No Shutter (recommended for strobe applications)
- Async Direct Shutter
- External VINIT with Pulse Width (No-Delay Shutter)

8.5.1 Async No Shutter

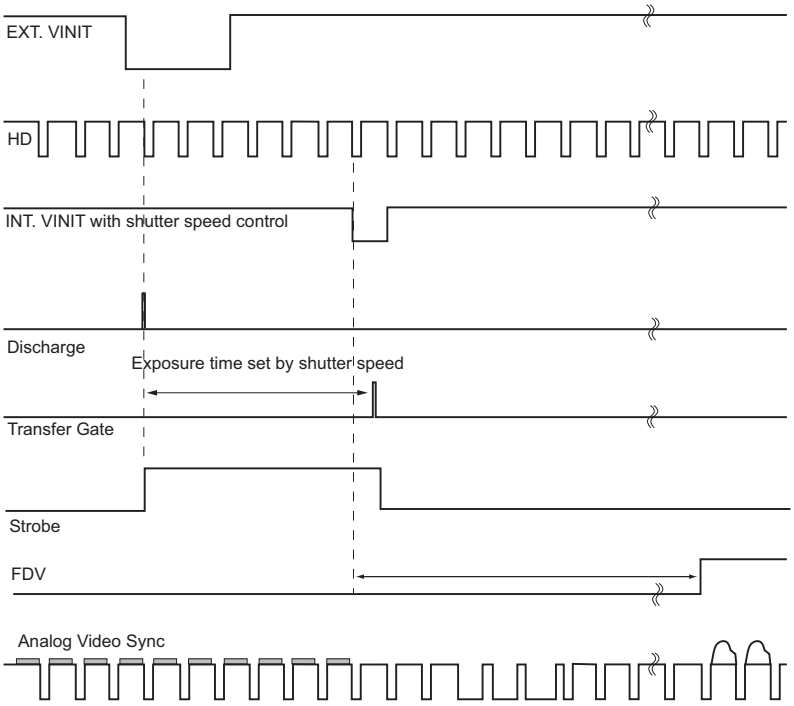
Async No Shutter allows for strobe and back-to-back strobing (strobing both before the transfer gate and right after) applications as shown in Figure 34.

Figure 34. Async No Shutter



8.5.2 Internal Direct Shutter Speed Control

Figure 35. Internal Direct Shutter Speed Control

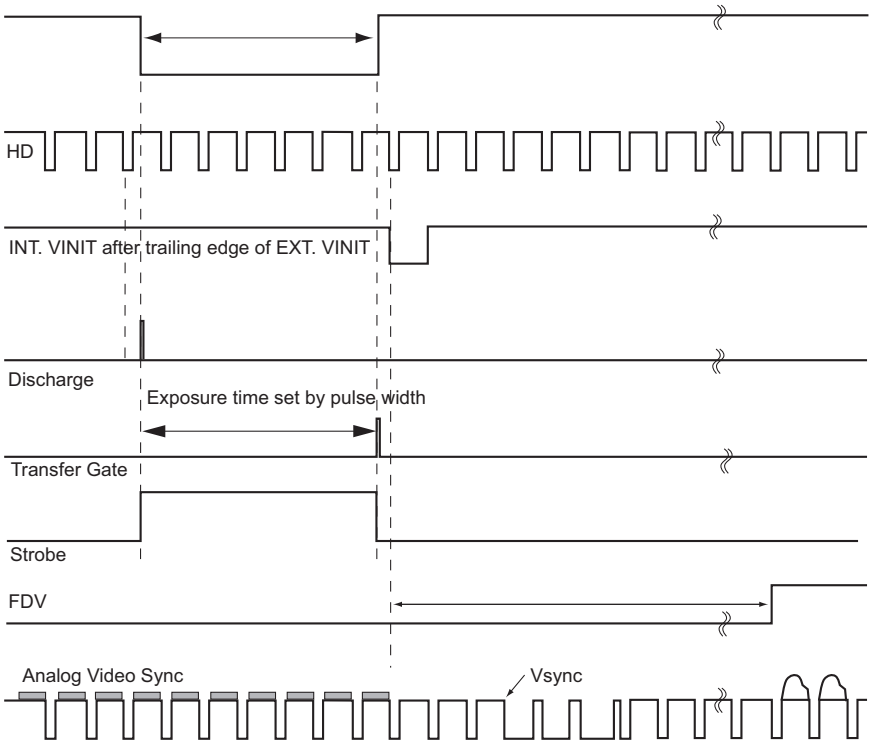


The video signal starts with internal VINIT. When the external VINIT pulse is applied, internal VINIT is latched to HD and the internal VINIT is delayed to set up the shutter speed period. The shutter speed is controlled by communication software. Video output timing starts right after the internal VINIT and single shots, FDV is output at the internal VINIT timing.

8.5.3 External VINIT With Pulse Width (No-Delay Shutter)

For multiple-camera applications such as 2D or 3D measurement and multi-angle inspection, simultaneous image capturing at an exact shutter timing for all cameras is a critical requirement. The TM-1405's asynchronous pulse-width control mode provides no-delay shutter (Figure 36) as standard. Regardless of the internal pulse timing, the camera discharges at the VINIT leading edge and transfers charges at the trailing edge of the pulse. Even though each camera runs with slightly different H and data clock timing, the image capturing is exactly simultaneous.

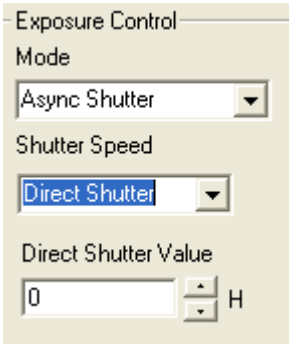
Figure 36. No-Delay Shutter



8.5.4 Async Direct Shutter

Async Direct Shutter exposure is determined by a direct shutter value entered from 1 to 1040. The shutter value equals 1.5H (horizontal line time) or 47.6 µsec. for each increment. The Async Direct Shutter exposure timing functions exactly the same as the internal shutter speed control. Async Direct Shutter is controlled by GigE camera acquisition software and sent serially through an Ethernet cable to the camera. The GUI interface that controls Async Direct Shutter exposure is illustrated in Figure 37 below.

Figure 37. Asynch Direct Shutter



8.6 Programmable Look-Up Table (LUT) and Knee Control

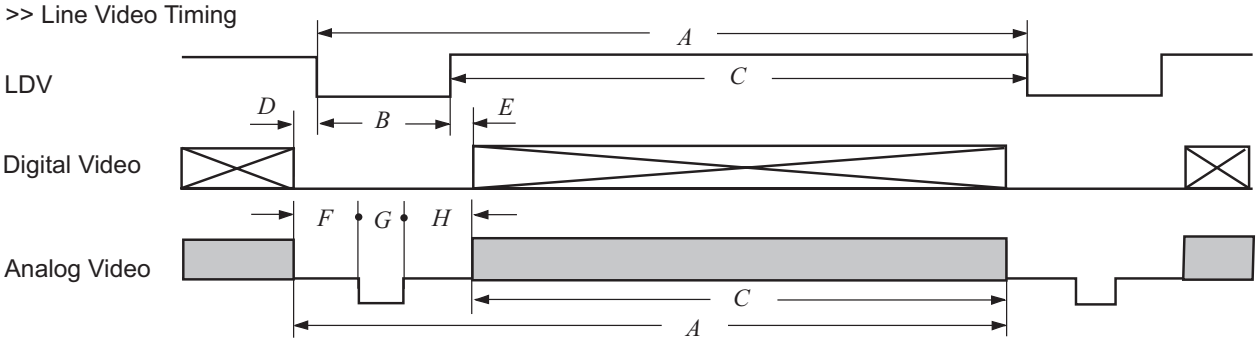
The TM-1405GE has a built-in LUT (look-up table) for dynamic range control. At a specific gain setting, the offset (minimum level.... dark point) and A/D reference top voltage (maximum level... saturation point) are set to 10-bit A/D input so that the full dynamic range of the CCD is utilized at 10-bit references as the input and the LUT output is converted into 8-bit to adjust the gamma correction. Notice that the LUT (look-up table) is not available in the 10-bit grayscale mode.

The look-up table has two knee points (variable gamma selection) that allow the 10-bit input to be segmented into three regions. The look-up table selection can be made by knee curve direct input.

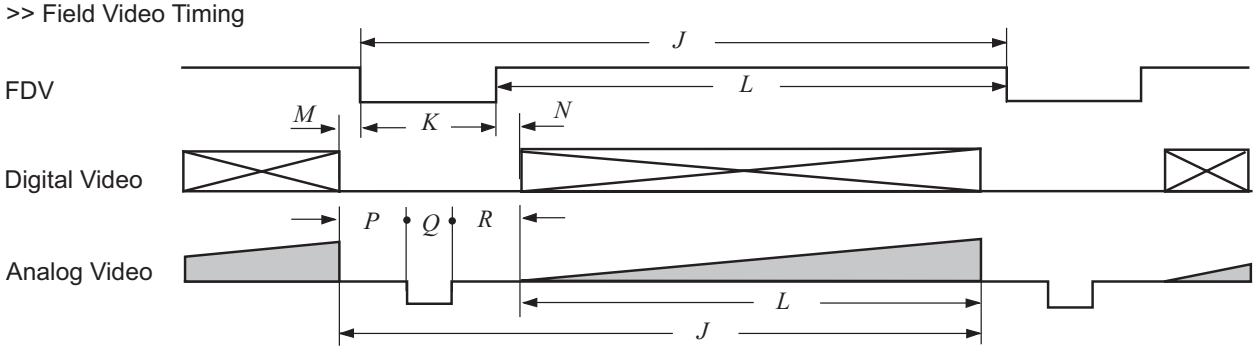
8.7 Camera Timing Charts

1. Video Output

>> Line Video Timing

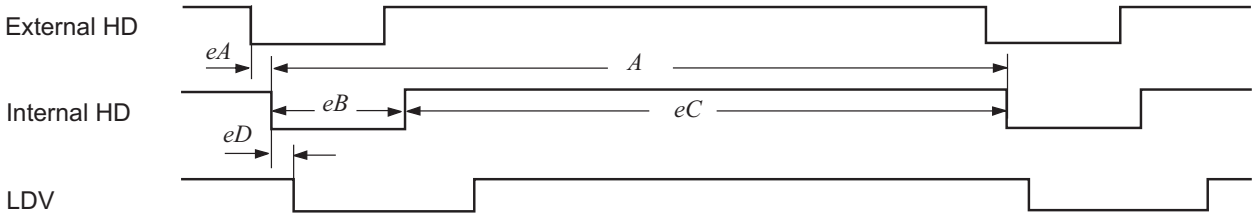


>> Field Video Timing

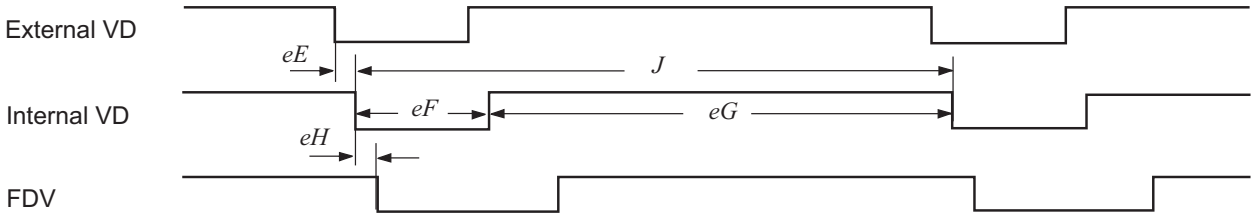


2. External HD Locking & External VD Reset

>> External HD Locking

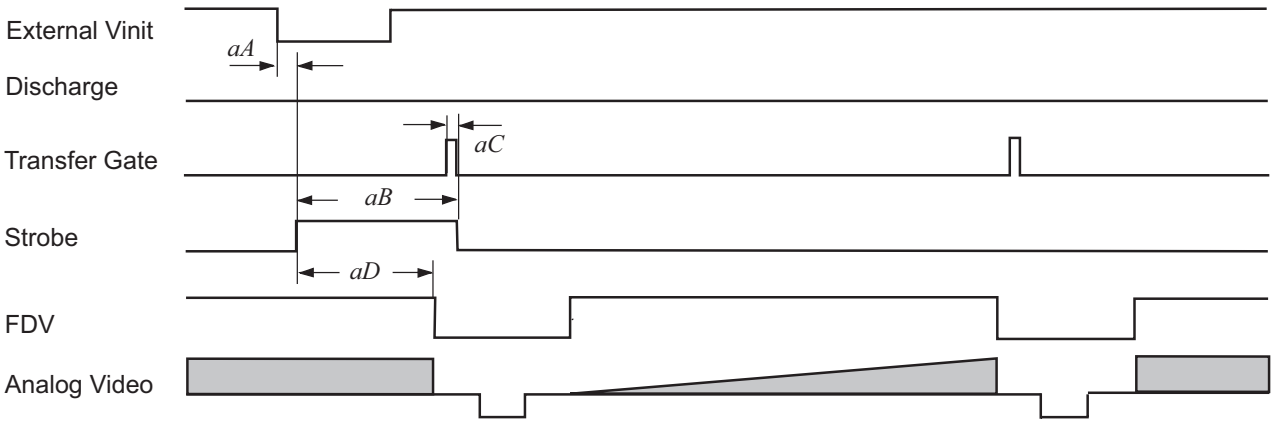


>> External VD Reset

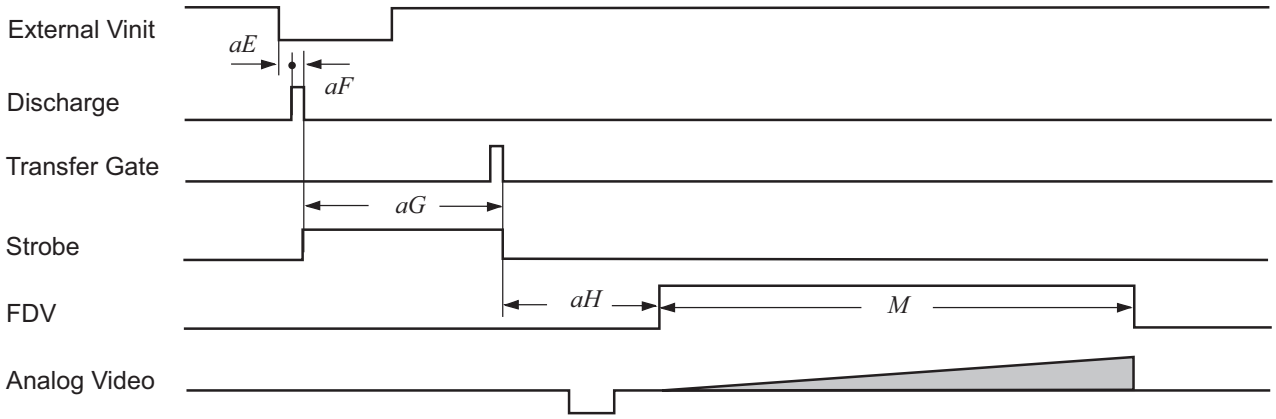


3. Async Reset

>> Async No Shutter



>> Async Direct Shutter & Async Pulse Width Control (Async No-delay Shutter)



8.8 Video Output

Table 7. Video Output (Horizontal Timing)

Horizontal Timing		
	Number of pixels	30fps **(μs)**
A	1608	32.16
B	216	4.32
C	1392	27.84
D	0	0
E	0	0
F	48	0.96
G	61	1.22
H	107	2.14

Table 8. Video Output (Vertical Timing)

	Vertical Timing			
	Full Scan Area		User Scan Area (SP:x, TL:y)	
	Number of lines	30fps **(μs)**	Number of lines	30fps **(μs)**
J	1053	33864.48	(nfp+11)+nrp+y	((nfp+11)+nrp+y)*32.12
K	13	418.08	(nfp+11)+nrp	((nfp+11)+nrp)*32.16
L	1040	33446.40	y	y*32.16
M	0	0	0	0
N	0	0	0	0
P	3	96.48	nrp+6	(nrp+6)*32.12
Q	3	96.48	3	96.48
R	7	225.12	nfp+5	(nfp+5)*32.16

Where

$$n_{fp} = \begin{cases} \text{int}(\frac{x+11}{6}) & \textit{remainder of } \frac{x+11}{6} = 0 \\ \text{int}(\frac{x+11}{6}) + 1 & \textit{remainder of } \frac{x+11}{6} \neq 0 \end{cases}$$

$$n_{rp} = \begin{cases} \text{int}(\frac{1042 - x - y}{6}) & \textit{remainder of } \frac{1042 - x - y}{6} = 0 \\ \text{int}(\frac{1042 - x - y}{6}) + 1 & \textit{remainder of } \frac{1042 - x - y}{6} \neq 0 \end{cases}$$

8.9 External HD Locking and External VD Reset

Table 9. External HD Locking and External VD Reset (Horizontal Timing)

Horizontal Timing		
	Number of pixels	30fps **(μs)**
eA	<1	<0.02
eB	160	3.20
eC	1448	28.96
eD	15	0.30

Table 10. External HD Locking and External VD Reset (Vertical Timing)

Vertical Timing				
	Full Scan Area		User Scan Area (SP:x, TL:y)	
	Number of lines	30fps **(μs)**	Number of lines	30fps **(μs)**
eE	<1	<32.16	<1	<32.16
eF	9	289.44	9	289.44
eG	1404	45152.64	(nfp+2)+nrp+y	((nfp+2)+nrp+y)*32.16
eH	0	0	0	0

8.10 Asynchronous Reset

Table 11. Asynchronous Reset

	(L: lines) (P: pixels)	**30 fps (μs)**
aA	<1L	<32.16
aB	9L + 960P	308.64
aC	160P	3.20
aD	9L	289.44

Table 12. Asynchronous Direct Shutter and Pulse-Width Control

	Asynchronous Direct Shutter (ADS=n)		Pulse-Width Control (Pulse Width=z)	
	(L: lines) (P: pixels)	30 fps (μs)	(L: lines)	30 fps (μs)
aE	<1L	<32.16	<10P	<0.2
aF	53P	0.972	36P	0.72
aG	(n+1)L+960P	(n+1)*32.16+1.92	z+960P	z+1.92
aH	K-1	(K-1)*32.16	K-1 to K	(K-1 to K)*32.16

9 Troubleshooting

9.1 Problems and Solutions

This section contains troubleshooting tips for common problems. Generally, problems can easily be solved by following these instructions. If the following remedies fail to offer a solution to your problems, contact a JAI PULNiX representative.

9.1.1 Symptom: No Video

Remedies: Check that the following are properly connected and operational.

- Power supplies
- Power cables
- Main power source
- Shutter control
- Async mode
- Lens
- Digital output cable
- Analog video cable

9.1.2 Symptom: Dark Video

Remedies: Check that the following are properly connected and operational.

- Shutter selection
- Iris opening on the lens

9.1.3 Symptom: Non-Synchronized Video

Remedies: Check that the following are properly connected and operational.

- Proper mode output
- Frame grabber software camera selection

9.2 Information and Support Resources

For further information and support:

Phone:	(408) 383-0300
	(800) 445-5444
Fax:	(408) 383-0301
E-mail:	imaging@jaipulnix.com
Mail:	JAI PULNiX, Inc.
	Sales Department
	625 River Oaks Parkway
	San Jose, CA 95134
	ATTN: Video Applications
Web Site:	www.jaipulnix.com

10 Appendix

10.1 Specifications

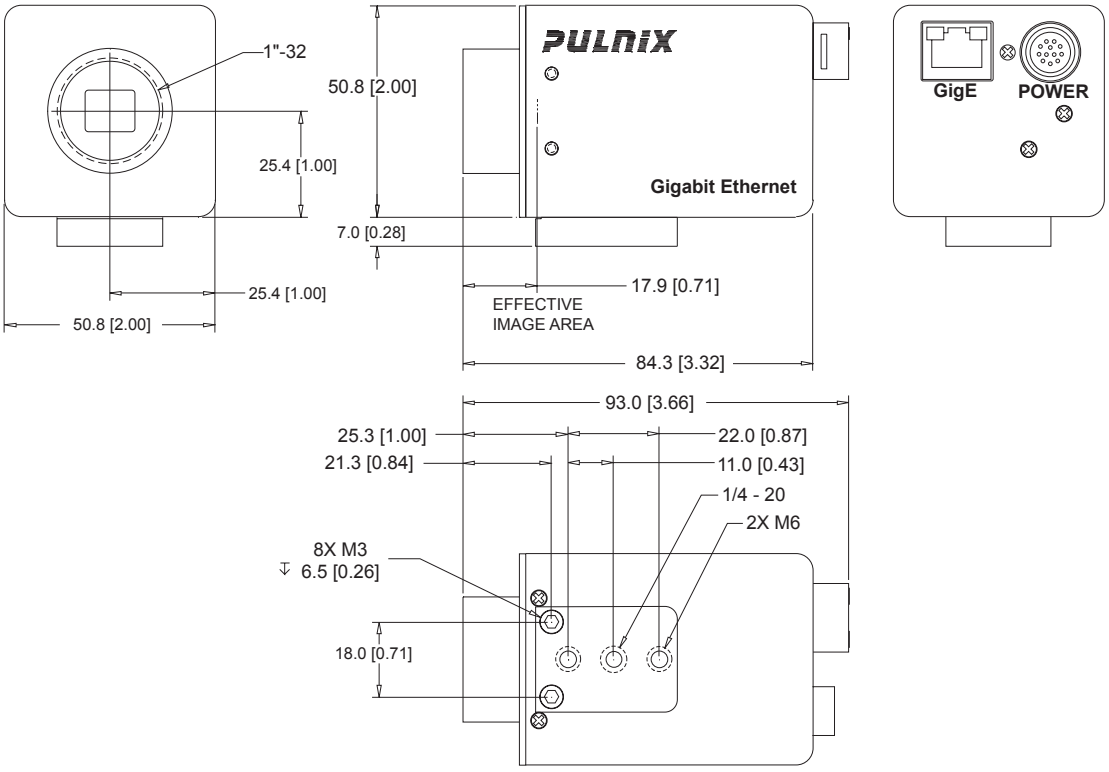
Table 13. TM-1405GE Camera Specifications Table

Feature	TM-1405GE
Imager	1/2” progressive scan interline transfer CCD
Active Area	6.47mm x 4.84mm
Active Pixels	1392 (H) x 1040 (V)
Cell Size	4.65µm x 4.65µm
Display Mode (Active Pixels)	1392 (H) x 1040 (V) @ 30 Hz
Sync	Internal/External auto switch HD/VD, 4.0 Vp-p impedance 4.7 K ohms VD=30.00 Hz±5%, non-interlace HD=31.1kHz±2%
Data Clock Output	50.00 MHz
Resolution	Digital: 1392 (H) x 1040 (V)
S/N Ratio	51dB min.
Min. Illumination	Monochrome= 0.3 lux; Color= 2.0 lux f = 1.4 without IR cut filter (no shutter) Sensitivity: 11.5µV/e-
Video Output	Analog: 714 mV, 75 ohms, (750 mV white clip) Digital output: 8-bit / 10-bit Gigabit Ethernet (selectable)
Gamma	Programmable LUT (1.0 std.)
Lens Mount	C-mount (use >1/2” format lenses or larger)
Power Requirement	12V DC, ±10%, 420mA 23°C, 12V DC (typical at 25°C)
Operating Temp.	-10°C to 50°C*
Vibration	7 Grms (10 Hz to 2000 Hz) Random, 11 ms half sine
Shock	70G
Size (W x H x L)	50.8mm x 50.8mm x 83.5mm
Weight	212 grams (7.47 oz.) without tripod
Optional Functions	OP 3-1, internal IR filter; OP 3-2, optical filter removal; OP 21, glassless CCD imager; OP 21-UV, QUV glassless CCD imager with quartz window
Optional Accessories **Power Cable** **Power Supply**	 12P-02S PD-12U series

*. Refer to Section 7.2.1 on page 32 for information on camera heat dissipation. Image quality degrades with increasing temperature.

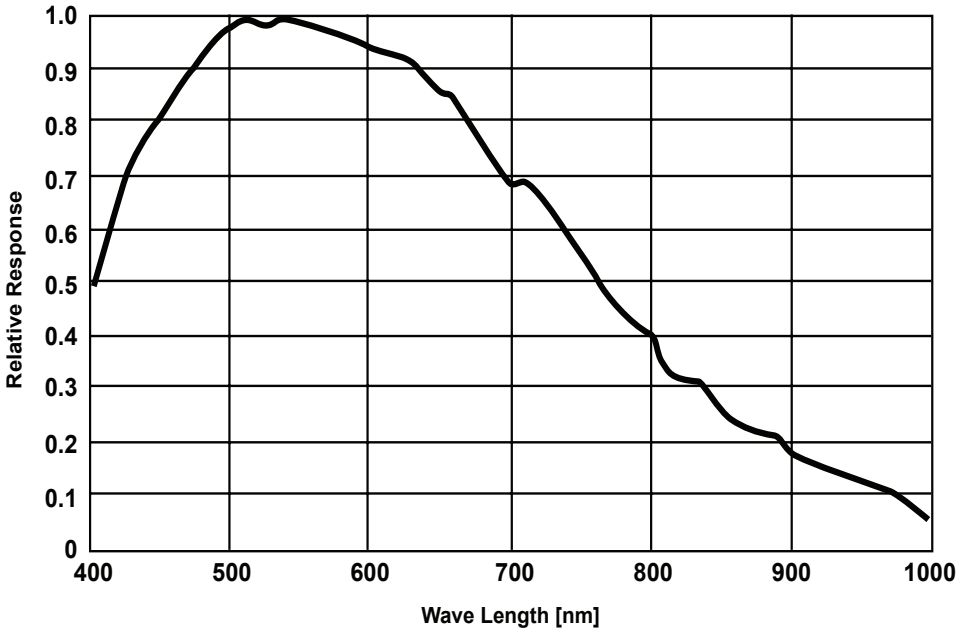
10.1.1 TM-1405GE Physical Dimensions

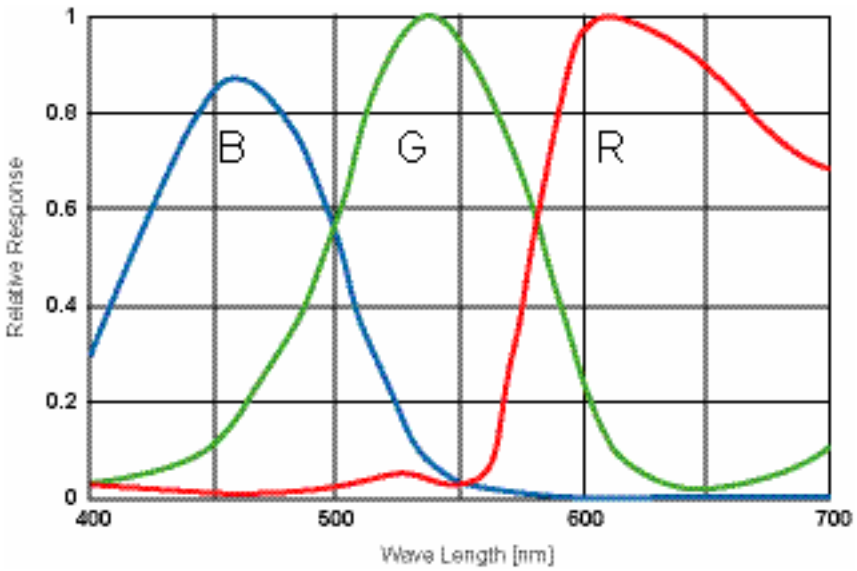
Figure 38. Physical Dimensions

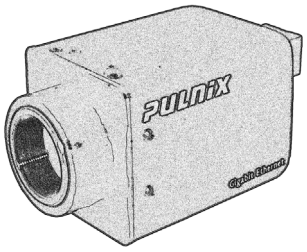


10.1.2 Spectral Response

Figure 39. Spectral Response







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